The Macroeconomic Consequences of Import Tariffs and Trade Policy Uncertainty*

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Abstract

We estimate the effects of import tariffs and trade policy uncertainty in the United States, combining theory-consistent and narrative sign restrictions on Bayesian structural vector autoregressions. Tariffs depress economic activity, both in the aggregate and across sectors and states. Uncertainty lowers imports and investment but raises exports. Both shocks tend to increase consumer prices and reduce employment. Both are macroeconomically relevant, explaining on average 5–10 percent of fluctuations in GDP. Historically, the 1990s free trade agreements triggered a prolonged investment and output boom, while widening the trade deficit. Undoing post-2016 protectionism would raise output by an additional 3 percent.

Keywords: Trade policy, international trade, structural vector autoregressions, narrative identification, general equilibrium, United States

JEL Codes: C32, E30, F13, F14

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1 Introduction

The uncertainty about US trade policy spiked around the 2016 and 2024 presidential elections. Since 2018, the US has raised import tariffs substantially. This return of protectionism has renewed the interest in two classic questions in international economics. What are the effects of import tariffs in large open economies? What are the effects of uncertainty about trade policy? Answers inform policymakers in the US, European Union, and China, who are all imposing political trade barriers. Two long-standing strands of research address these questions. So far, both strands mainly use microeconomic data, analyze the two questions in isolation, and focus on selected trade episodes. A macroeconomic account of the effects of both dimensions of US trade policy in a unifying framework and over many trade events is largely missing.

This paper aims at filling the gap. We estimate the general equilibrium effects of import tariffs and trade policy uncertainty in the US since the 1960s. Our identification approach combines two traditions in the empirical macroeconomic literature, theory and narrative information, to disentangle the effects of shocks to the level and uncertainty of trade barriers. We contribute to the literature on international trade along three main dimensions.

First, the empirical trade literature is mainly based on microeconomic data. For example, Fajgelbaum et al. (2019) estimate the impact of trade impediments in partial equilibrium. Then, they embed these estimates in a structural general equilibrium model. This approach delivers sharp identification and detailed insights into the economic mechanisms. But the aggregate effects are based on potentially strong behavioral and parametric assumptions and refer to the long run as they are based on comparative statics. We complement these insights by starting from the opposite side. We estimate the short run general equilibrium effects using a flexible empirical framework in form of a Bayesian structural vector autoregression (SVAR) with minimal assumptions. Then, we use the identified shocks to determine the disaggregated impacts across US sectors and states.

The second contribution is to estimate both dimensions of US trade policy, shifts in the level of tariffs and in the uncertainty around these, in one encompassing model. By contrast, most of the empirical trade literature analyzes them separately.[1] However, tariff changes and trade

[1] Autor et al. (2016) and Fajgelbaum and Khandelwal (2022) review the literature on the effects of tariff changes and Handley and Limão (2022) the literature on the impact of trade policy uncertainty. Alessandria et al. (2025a) are one of the few exceptions who analyze both changes in the level and uncertainty of tariffs in one framework. They

policy uncertainty often go hand in hand, as the recent US trade disputes illustrate. In addition, identifying both level and uncertainty shifts within a single model has the advantage that we can compare the implications and importance of both dimension of trade policy consistently.

The third contribution is to complement the existing estimates based on single trade events, or shorter samples, with evidence from 60 years of quarterly data, containing previously considered events but also longer swings in US trade policy. For example, several studies investigate the impact of China's WTO accession in 2001 (Autor et al., 2013; Handley and Limão, 2017) or of more recent US trade conflicts (Amiti et al., 2019; Flaaen et al., 2020; Cavallo et al., 2021). Others use granular data that start in the 1990s (Barattieri and Cacciatore, 2023; Boehm et al., 2023). These studies provide valuable insights into specific episodes and trade policies. We add evidence on the macroeconomic effects of shifts in trade policy since the 1960s.

Identifying both level and uncertainty shifts in one model is challenging and the literature has not centered on a standard approach. We use sign restrictions for that purpose and identify first and second moment shocks to trade policy. The restrictions can either come from theory (Uhlig, 2005) or from historical records (Antolín-Díaz and Rubio-Ramírez, 2018). We combine both pieces of information. For theory, we set-up a canonical two-country dynamic stochastic general equilibrium (DSGE) model, as used by Erceg et al. (2023) for example, to which we add stochastic volatility of import tariffs. We perform a prior-predictive analysis of the model to derive sign restrictions for the impulse responses of the Bayesian SVAR that are robust to parameter uncertainty. We augment the theory-based restrictions with narrative information on key historical episodes of US trade policy. We estimate the empirical model on quarterly US macroeconomic data for the 1960Q1-2019Q4 period, including more recent trade disputes as well as earlier ones.[2] The model includes customs duties and an index of trade policy uncertainty to capture first and second moment shocks to US trade policy. We remain agnostic about the signs of the effects on key outcome variables like GDP, employment, or the trade balance.

Regarding our first contribution, we find that both shocks have broad macroeconomic effects. Restrictive tariff level shocks reduce imports, exports, and investment strongly. The effects are

study Chinese exports to the US, leveraging China's switch to most-favored nation status in 1980 in a structural trade model with a time-varying probability of regime switching.

[2]The sample contains, for example, the Nixon shock in 1971, Ford's tariffs on energy imports in 1975, the GATT Kennedy, Tokyo and Uruguay Rounds concluding in 1967, 1979 and 1994, the creation of NAFTA in 1994, and the tariff increases in 2018/19.

very persistent, lasting for 5-10 years. Consumer prices tend to rise and the exchange rate to appreciate. Despite an improvement of the trade balance, output falls persistently below trend because all private domestic demand components contract, especially investment. A one standard deviation positive tariff shock that raises tariff revenue by 5% lowers output by 0.2% below trend for many years. From the responses, we compute a general equilibrium import elasticity of –7 in the short run and –12 in the long run. Results from local projections of sectoral data on the tariff shocks suggest that imports, exports, investment, and employment fall in the majority of sectors. Projections on regional data show that employment declines in nearly all US states. Trade policy uncertainty shocks also affect macroeconomic dynamics. They depress imports and investment and are inflationary. Output has a tendency to decline but is less affected because of a tentative exchange rate depreciation that supports exports and partially compensates the domestic demand contraction. Nevertheless, employment falls. Across sectors, imports, investment, and employment mostly fall, while exports increase. The regional employment effects are mostly negative for coastal and Rustbelt states, while some commodity exporting states in the Middle-West profit from the exchange rate depreciation.

As to the second contribution, we document similarities but also differences in first and second moment trade policy shocks. Tariff shocks are more detrimental than trade policy uncertainty shocks. Tariffs weigh particularly on domestic investment and thereby depress output notably. They lower imports *and* exports. Trade policy uncertainty shocks reduce imports and investment, too, but they raise exports such that the negative output effects are attenuated. On the other hand, uncertainty shocks are strongly inflationary, whereas the price effects of tariffs are smaller and imprecisely estimated. We quantify the average importance of the two types of shocks. Both are macroeconomically relevant. They explain 5-10% of the unexpected variation in US output.

For the third contribution, we estimate and compare the macroeconomic effects of shifts in US trade policy since the 1960s. Historical decompositions show that the Nixon and Ford tariff shocks in 1971 and 1975 left only small and short scars on the US economy. Against this, the swing from protection in the 1980s (mainly vis-à-vis Japan) to free trade in the 1990s (CUSFTA/NAFTA, GATT/WTO) had large and long-lasting positive effects: the further opening of the economy increased domestic investment by up to nine log points above trend for twenty years and raised output by up to three log points. These gains from less restrictive trade policy coincided with a widening of the trade deficit by around one percentage point, suggesting that the bulk of the movements in the US trade deficit were due to other forces. The general equilibrium effects of the free trade agreements on total employment were generally small but slightly positive. The return to protectionism since 2016 reversed the pattern. While it narrowed the trade deficit, it reduced GDP, investment, and total employment. The estimated output costs for 2018/19 are 1.5%. Going forward, a structural scenario analysis suggests that reducing tariffs and uncertainty to their pre-2016 levels would raise output by 3% above the status quo level after three years.

Relation and contribution to literature. The findings relate and contribute to three strands of research on trade policy. First, the traditional empirical trade literature provides evidence based on microeconomic data. As a recent example, Barattieri and Cacciatore (2023) study the impact of temporary trade barriers on production networks and find no significant effects on employment in upstream industries and negative effects in downstream sectors. A long list of articles estimates partial equilibrium import elasticities from gravity equations using detailed product and tariff data. Head and Mayer (2014) summarize them and report a mean elasticity of –7 with a standard deviation of 9. We complement these insights with dynamic general equilibrium estimates. The macroeconomic literature on trade policy in large open economies is mainly theoretical. Going back to Mundell (1961), Keynesian models typically predict that a rise in domestic tariffs has contractionary effects under flexible exchange rates as the terms of trade improve, savings rise, and domestic demand falls.[3] We show that, and how, these theoretical predictions and the existing microeconomic estimates bear out in aggregate data. We obtain a general equilibrium elasticity of –7 in the first year and of –12 after eight years.

Other microeconometric studies focus on the effects of the uncertainty that surrounds trade policy. Using China's accession to the World Trade Organization (WTO) in 2001 as a natural experiment, Pierce and Schott (2016) document that the associated decrease in uncertainty about import tariffs boosted bilateral trade but reduced manufacturing employment in US industries more exposed to the change; Handley and Limão (2017) show that it raised Chinese exports to the US and lowered US prices significantly; and Feng et al. (2017) document a similar pattern for Chinese and

[3]Chan (1978) and Krugman (1982) substantiate Mundell's findings under extensions of nominal rigidities and money markets. Eichengreen (1981, 1983) finds that the effect can shortly be expansionary before turning recessionary in a dynamic open macro portfolio balance model. While we share the theoretical foundations with this earlier literature, our focus is empirical.

European firms. Conversely, Alessandria et al. (2019) highlight wait-and-see behavior of US firms before China's accession that dampened trade. Crowley et al. (2018) use data on Chinese firms and document that firms subject to higher trade policy uncertainty engage less in international trade. We complement the microeconomic evidence by showing how the partial equilibrium effects transmit to the macroeconomy. While we confirm that lower trade uncertainty raises US imports, we do not observe that it lowers US aggregate employment. Actually, it raises it slightly, suggesting that the adverse effects on firms or industries strongly exposed to the event are more than offset by positive effects on other parts of the economy. In this sense, our results paint a more benign picture of the likely uncertainty effects of China's WTO accession on the US economy.

The second strand of related literature aims at estimating the effects of economic (policy) uncertainty. The standard approach is to assume exclusion restrictions between first and second moment shifts (Bloom, 2009; Baker et al., 2016). However, there is little theoretical guidance for such restrictions and in practice some researchers order uncertainty first and others the level of variables. In addition to the theoretical doubts, Kilian et al. (2025) show that exclusion restrictions are empirically invalid for identifying uncertainty shocks. A few articles allow for simultaneous feedback between first and second moments (Piffer and Podstawski, 2018; Berger et al., 2020; Ludvigson et al., 2021). These propose using instruments, shock restrictions, a combination of both, or options prices to disentangle level and uncertainty shocks. They study the impact of general macroeconomic or financial uncertainty. We complement this evidence by focusing on trade policy first and second moment shocks. We document that both are important but that first moment trade policy shocks are more harmful for economic activity because they do not entail a partially offsetting exchange rate response.[4] Moreover, we propose using sign restrictions derived from a DSGE model to disentangle first and second moment shocks.

The third strand of related literature focuses on the US-China trade relations and in particular the trade war since 2016. Amiti et al. (2019) find that US tariffs have reduced imports and increased prices. Fajgelbaum et al. (2019) reach a similar conclusion. The authors find complete pass-through of tariffs to US consumer prices and estimate welfare costs for US consumers of 0.3% of GDP. Cavallo et al. (2021) document complete pass-through at the border but not to retail

[4] Another difference to the articles that look at macroeconomic or financial uncertainty is that these uncertainty measures affect domestic firms directly, whereas trade policy uncertainty is more relevant for foreign exporters.

prices, suggesting a decrease in domestic markups. Flaaen et al. (2020) provide evidence that US import tariffs on washers raised consumer prices more than one-to-one.

We complement these insights with estimates of the average pass-through of US tariffs to import prices since the 1960s and with estimates of the macroeconomic consequences of two specific tariff changes, China's WTO accession and the 2018/19 trade war. We find that import prices decline on average following higher tariffs, suggesting that the US has historically been able to affect world prices. Furthermore, our historical decompositions suggest a more positive assessment of China's WTO accession than in Autor et al. (2013), who document in a difference-in-difference setting that it led to job losses in particularly exposed US sectors. We find that the effects of US trade policy shocks on aggregate employment during the years 1990-2010 were small and if anything positive. Moreover, we document that the shocks set off a sustained investment and output boom. Accordingly, our model also yields larger estimates of the costs of the 2018/19 trade war than the comparative statics in Fajgelbaum et al. (2019). The high persistence of our estimated impulse responses suggests that adjustments to trade policy shifts can last several years and neglecting the transitional dynamics may lead to underestimating the costs of policy changes. Especially the endogenous adjustment of the capital stock seems to play an important, as emphasized by recent dynamic trade models (Mix and Hoang, 2025).

The remainder of the paper is structured as follows. Section 2 describes the data, the empirical methodology, and the theoretical framework. Section 3 presents the results. Section 4 summarizes the robustness, while Section 5 concludes.

2 Empirical strategy and data

2.1 Bayesian SVAR and data

We estimate a reduced form Bayesian VAR that has the following form:

$$y_t = \nu + \sum_{i=1}^{p} A_i y_{t-i} + u_t, \tag{1}$$

where y_t denotes the vector of endogenous variables, ν is a vector of intercepts, A_i are regression coefficient matrices, and u_t mean-zero $i.i.d.$ reduced form errors with covariance matrix $\mathbb{E}(u_t u_t') = \Sigma$. y_t contains quarterly data on real GDP, real goods exports, real goods imports, the consumer price index, the nominal effective exchange rate, real customs duties, and trade policy uncertainty for the United States from 1960Q1 to 2019Q4. All series enter in log levels. We deflate nominal variables by the consumer price index. Table A.2 provides details about the sources, data, and variable construction.

We use customs duties, i.e., tariff revenue, to capture shocks to the level of tariffs. We employ the news-based measure of trade policy uncertainty from Caldara et al. (2020) to identify trade policy uncertainty shocks.[5] The index is based on occurrences of US newspaper articles that contain terms related to both trade policy and uncertainty. We include imports, exports, consumer prices, the exchange rate, and output in y_t as key economic outcomes of interest. Furthermore, these variables allow disentangling tariff shocks and trade policy uncertainty shocks from each other, as well as from domestic demand and supply shocks. The order of the variables does not matter as we do not rely on a recursive identification. We estimate equation (1) with $p = 4$ as we have quarterly data.

Figure 1 displays the evolution of the effective tariff rate, measured as customs duties relative to goods imports since 1960 in the upper panel. The tariff rate fluctuates between 9.0 and 1.5 percent of goods imports. Its overall trend is decreasing over our sample horizon. It fell roughly by half from 1965 to 1980, picked up slightly until the early 1990s before reaching a rather constant low level in the 2000s. The rate spiked in 1971 and 1975 as well as during the US-China trade war in 2018. Trade policy uncertainty (lower panel) spiked in 1971, 1975 and 1993; but the spikes are low compared to the period after 2015.

The reduced form VAR in (1) can be expressed in a structural form as

$$B_0 y_t = \vartheta + \sum_{i=1}^{p} B_i y_{t-i} + \varepsilon_t, \tag{2}$$

where ε_t are independent structural shocks. These are related to the reduced form errors via the

[5] The news-based measure of Baker et al. (2016) starts only in 1985 and the earnings calls-based measures of Caldara et al. (2020) and Hassan et al. (2019) in the 2000s.

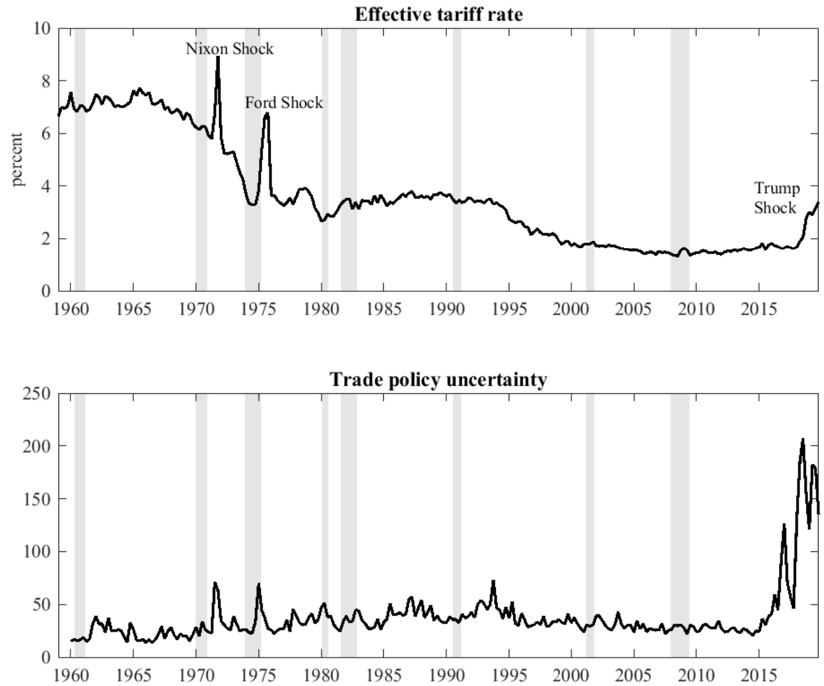


Figure 1: Effective tariff rate and trade policy uncertainty index. *Notes:* The vertical grey areas represent NBER recession dates. The effective tariff rate is calculated as US customs duties relative to goods imports. The news-based trade policy uncertainty index is from Caldara et al. (2020).

linear transformation $u_t = B_0^{-1}\varepsilon_t$. Thus, B_0^{-1} contains the impact effects of the structural shocks on the endogenous variables in y_t. By assuming a unit variance for the uncorrelated structural shocks, $\mathbb{E}(\varepsilon_t\varepsilon_t') = I_n$ (an n x n identity matrix), the reduced form covariance matrix Σ is related to the structural impact matrix as $\Sigma = \mathbb{E}(u_t u_t') = B_0^{-1}\mathbb{E}(\varepsilon_t\varepsilon_t')B_0^{-1\prime} = B_0^{-1}B_0^{-1\prime}$. The coefficients of the reduced form are related to the coefficients of the structural form as $A_i = B_0^{-1}B_i$ and $\nu = B_0^{-1}\vartheta$.

2.2 Identification

To identify the structural parameters, we apply traditional sign restrictions, following Faust (1998) and Uhlig (2005), and narrative sign restrictions, following Antolín-Díaz and Rubio-Ramírez (2018). We place the traditional sign restrictions on the impact matrix B_0^{-1}.

2.2.1 Theoretical restrictions

We derive the traditional sign restrictions from a prior-predictive analysis of a canonical large open economy macroeconomic model. It is similar to the model of Erceg et al. (2023), featuring monopolistic competition, nominal frictions, nontradable goods, home bias, and incomplete international financial markets. The model consists of two countries with a constant number of households and firms. The countries are symmetric in their structure but may differ in size. We think of country 1 as the US and of country 2 as the rest of the world. We assume dominant currency pricing in country 1 currency, following Gopinath et al. (2020). Appendix A.5 shows that the sign restrictions we derive for identification are robust to producer and local currency pricing.

We keep the model tractable so that we can solve it many times with third-order perturbation methods to derive a range of impulse responses to level and uncertainty shocks for alternative parameter values. We use a model with sticky prices as the SVAR is estimated on quarterly data and identified with short run restrictions (on the impact response). Pricing frictions are likely important for the behavior of quantities and prices at that frequency. Models with real trade frictions, such as sunk export costs, are typically used for the annual frequency and to model transitions between steady states (Alessandria et al., 2021). Moreover, Caldara et al. (2020) show that sunk export costs amplify trade and investment responses to tariffs but do not alter their impact signs.

We sketch the production sector and in particular the problem of the composite tradable goods producers in country 1 to illustrate how we model the tariff level and uncertainty shock. Appendix A contains the full model. Production of tradables proceeds at two stages. At the upstream, firms are imperfectly competitive. They produce differentiated intermediate tradable goods. The number of firms corresponds to the number of households in each country and firms are indexed by z. Firm $z \in [0, n]$ is located in country 1 and firm $z \in (n, 1]$ in country 2. Intermediate goods are used at the downstream in both countries by perfectly competitive firms that produce a composite tradable good $Y_{T,t}$ with a CES production function:[6]

$$Y^1_{T,t} = \left[\left(\frac{1-(1-n)\,h}{n} \right)^{\frac{1}{\theta}} \int_0^n y_t^{1,1}(z)^{\frac{\theta-1}{\theta}}\, dz + h^{\frac{1}{\theta}} \int_n^1 y_t^{2,1}(z)^{\frac{\theta-1}{\theta}}\, dz \right]^{\frac{\theta}{\theta-1}}, \tag{3}$$

with $\theta > 1$ the elasticity of substitution and $h \in [0,1]$ the degree of home bias. $y_t^{1,1}(z)$ is an intermediate tradable good produced by firm z and used domestically, $y_t^{2,1}(z)$ the intermediate tradable good produced in country 2 and imported, and n denotes the size of country 1. $h = 1$ is no home bias, and $h = 0$ no international trade. The input weights are adjusted for country size.

The producer solves the profit maximization problem

$$\max_{y_t^{1,1}(z),\, y_t^{2,1}(z)} P^1_{T,t} Y^1_{T,t} - \int_0^n p_t^1(z)\, y_t^{1,1}(z)\, dz - \int_n^1 \left(1+\tau_t^1\right) q_t^1(z)\, y_t^{2,1}(z)\, dz$$

subject to the production function (3), where $P^1_{T,t}$ is the composite tradable good price, $p_t^1(z)$ and $q_t^1(z)$ are the prices of the intermediate tradable goods in the dominant currency. τ_t^1 is an ad-varlorem import tariff of country 1 at the border.

The first order conditions to the maximization problem yield the demand for foreign intermediate tradable good z:

$$y_t^{2,1}(z) = h \left(\frac{\left(1+\tau_t^1\right) q_t^1(z)}{P^1_{T,t}} \right)^{-\theta} Y^1_{T,t}.$$

Import demand depends, other things equal, negatively on the tariff rate. The zero profit condition implies that the price of the composite tradable is

$$P^1_{T,t} = \left[\frac{1-(1-n)\,h}{n} \int_0^n p_t^1(z)^{1-\theta}\, dz + h \int_n^1 \left(\left(1+\tau_t^1\right) q_t^1(z) \right)^{1-\theta} \right]^{\frac{1}{1-\theta}},$$

showing that higher tariffs raise prices ceteris paribus.

The tariff rate in country 1 follows an AR(1) process with stochastic volatility:

$$\begin{aligned} \tau_t^1 &= (1-\rho)\,\tau^1 + \rho \tau_{t-1}^1 + \omega_{t-1}\varepsilon_t \\ \omega_t &= (1-\rho)\,\omega + \rho\omega_{t-1} + \mu\nu_t, \end{aligned}$$

[6] In each country, the composite tradable good is combined with domestic nontradable goods with a CES aggregator to produce a final consumption good.

where ε_t and ν_t are *iid* standard normal innovations to the level and variance of tariffs, respectively, and variables without time-subscript denote their steady state. We refer to τ_t^1 as tariff shocks and to ω_t as trade policy uncertainty shocks. We allow for retaliation of country 2 in an ad-hoc form:

$$\tau_t^2 = (1-\rho)\,\tau^2 + \rho\tau_{t-1}^2 + \zeta\omega_{t-1}\varepsilon_t,$$

with $\zeta \in [0,1]$. $\zeta = 0$ is no retaliation and $\zeta = 1$ is full retaliation. We also include a standard demand shifter and technology shock in country 1 to derive sign restrictions for the identification of domestic demand and supply shocks.

We calibrate a handful of parameters and for the others we specify prior distributions that are typically used for the linear Bayesian estimation of such models. The calibration and distributions are mostly standard and thus deferred to Table A.1. Here, we briefly discuss two important choices. First, Figure 1 suggests considerable persistence in US trade policy.[7] Therefore, we allow for an arbitrarily high autocorrelation of both the level and uncertainty shock, but rule out permanent shocks to ensure stationarity of the model, by specifying a beta distribution for ρ with a fairly high mean of 0.9 and a standard deviation of 0.025. Second, the retaliation parameter ζ is not standard. We use a beta distribution with mean 0.5 and wide standard deviation of 0.25. While there is no database that systematically documents the degree of retaliation, Evenett (2024) calculate that the probability of EU and Chinese retaliation to US protectionism ranged between 0.2 and 0.8 across product categories for the period 2021-2023.

From the prior distributions, we draw 5000 parameter combinations. For each, we compute the responses to the four types of shocks. For the uncertainty shock, we compute a third-order approximation with pruning and simulate the model for 1000 periods without shocks to obtain the stochastic steady state, that is, the ergodic mean in the absence of shocks. We discard the first 1000 periods as burn-in and feed in an uncertainty shock that doubles the standard deviation of the tariff level shocks.

Figure 2 shows in the top panels the frequency distributions of the impact responses of country 1 to a tariff rate shock in country 1 that raises customs duties by 1% on average. It reports the variables of the DSGE model that correspond to the endogenous variables in y_t of the SVAR in

[7] Appendix section C.3.2 estimates the autoregressive process with stochastic volatility for tariffs using a particle filter following Caldara et al. (2020).

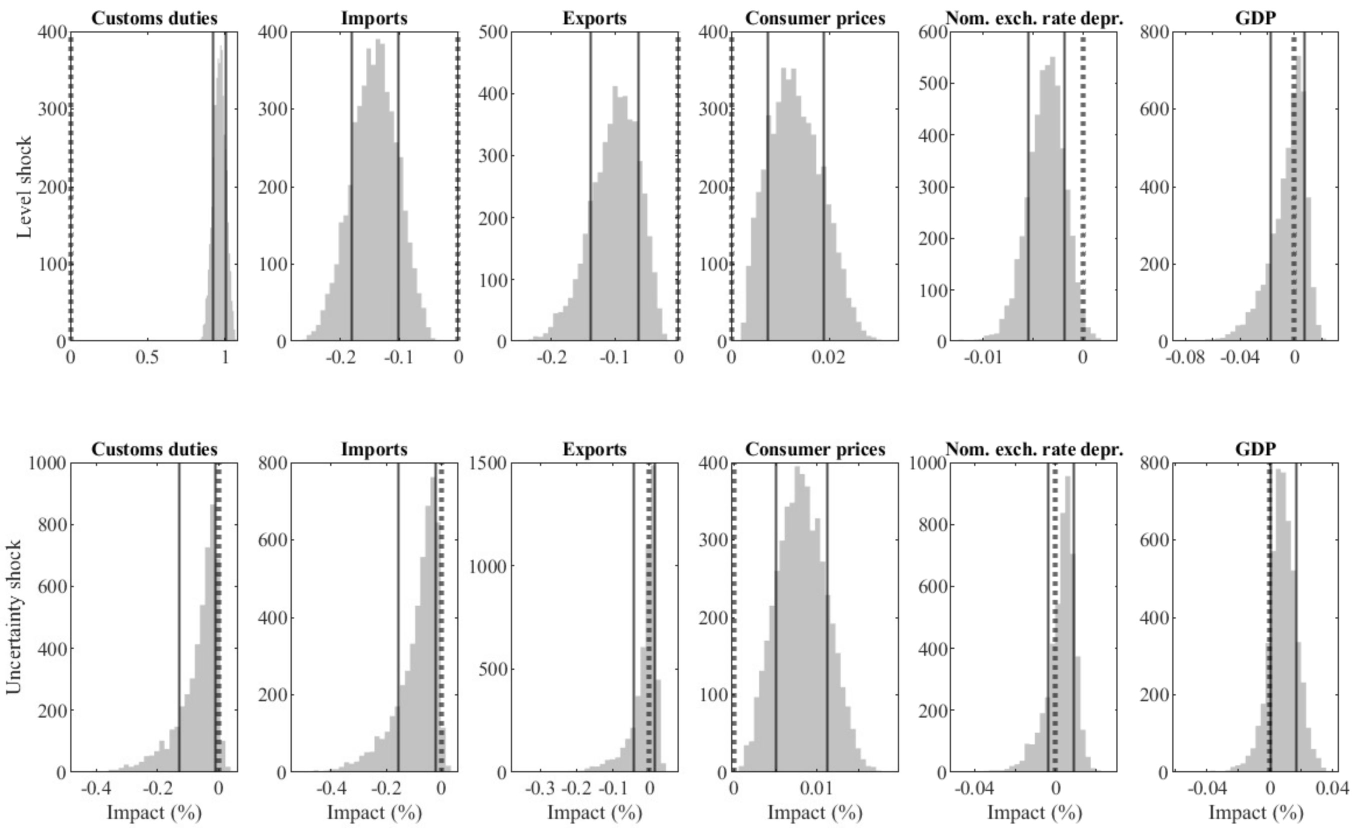


Figure 2: Frequency distributions of impact responses. *Notes:* The figure shows the frequency distributions of the impact responses to a tariff rate shock of country 1 that raises customs duties by 1% in the upper panels and to a shock that doubles the standard deviation of the innovations to the level of the tariff rate in the lower panels. The shaded areas show the frequency distribution and the solid vertical lines the 68% credible set. Zero is indicated by a dashed vertical line.

(2). The solid vertical lines refer to the 68% credible sets. The dashed vertical lines denote zero. The tariff rate shock increases customs duties upon impact, implying that the model is on the left side of the Laffer curve for all parameter values. Higher tariffs raise the domestic price of imported goods, such that imports fall. Higher prices feed into consumer prices, which rise. The nominal exchange rate appreciates due to expenditure switching toward domestic goods, which entails a reduced demand for foreign currency by domestic households. The real exchange tends to appreciate as well (not shown). Exports fall with the real appreciation and because of partial retaliation of country 2.

Figure 2 presents in the bottom panels the frequency distributions of the impact responses of country 1 to an uncertainty shock in country 1 that doubles the standard deviation of the innovations in the tariff level equation. As uncertainty about import tariffs rises, domestic firms raise prices and markups in precaution. Fernández-Villaverde et al. (2015) provide the theoretical foundations of such an upward pricing behavior. Caldara et al. (2024) add evidence based on data since 1900 for 44 economies that inflation increases in response to higher risk. Higher import prices lower demand and imports fall. As the tax base declines, customs duties fall as well. Higher producer prices feed into consumer prices, which increase. Domestic households want to increase precautionary saving such that there is a tendency for the exchange rate to depreciate. As imports drop and exports react little, the trade balance tends to increase (not shown), which pushes up output.[8]

Table 1 shows in the first column the sign restrictions that we derive from the prior-predictive analysis to identify tariff shocks in the Bayesian SVAR in (2). As the impact responses of customs duties, imports, exports, consumer prices, and the nominal exchange rate are all credibly different from zero according to the 68% credible sets (Figure 2), we impose the implied signs on the impulse responses in the first quarter. In contrast, the sign of the output response is ambiguous and depends on the parameter combination. Hence, we do not impose a sign restriction on the output response. In the spirit of Uhlig (2005), we stay agnostic and let the data decide on the sign (and magnitude) of this main outcome variable. Overall, the sign restrictions are in line with standard (Keynesian) open economy models (Mundell, 1961; Chan, 1978; Krugman, 1982; Barattieri et al., 2021; Caldara et al., 2020; Erceg et al., 2023).

The second column reports the sign restrictions for the identification of trade policy uncertainty shocks. As the responses of customs duties, imports, and consumer prices are all distinguishable from zero according to the credible sets (Figure 2), we impose these restrictions on the impact responses. Again, we leave the output response unrestricted because the model predictions are ambiguous and since we want to let the data decide about the sign of the effect.[9]

[8] The tentatively positive output effect is a difference to Caldara et al. (2020) who find a negative response. They assume full retaliation, which eliminates the differential demand and saving effects and depresses output in both countries. In any case, we will not use the sign of the output response for the identification of trade policy uncertainty shocks.

[9] We ensure that the sign restrictions for the level and uncertainty shocks are robust to using extreme values for the retaliation parameter. For the uncertainty shock, the sign restrictions are robust to setting ζ either to 0 or 1 (instead of using the prior distribution with mean 0.5). For the level shock, all sign restrictions are robust to setting $\zeta = 0$ and all but the exchange rate response are robust to setting $\zeta = 1$. The upper threshold to obtain a credible exchange rate appreciation is around $\zeta = 0.85$.

Variable	Shock Tariff	TPU	Supply	Demand
Customs duties	+	−	∗	+
Trade policy uncertainty	∗	+	∗	∗
Imports	−	−	∗	+
Exports	−	∗	+	∗
Consumer prices	+	+	−	+
Nominal exchange rate	−	∗	−	+
GDP	∗	∗	+	+

Table 1: Sign restrictions on impact responses. *Notes:* The table shows the sign restrictions on the impact responses of the Bayesian SVAR in (2) used to identify shocks to the tariff level, trade policy uncertainty (TPU), domestic demand, and domestic supply. A decrease in the nominal exchange rate denotes a US-Dollar appreciation. Customs duties, GDP, imports, and exports are in real terms. * denotes no restriction.

Comparing the sign restrictions on customs duties between the level and uncertainty shock highlights a main advantage of working with duties instead of with an average effective tariff rate (quarterly data on statutory tariffs are not available). For duties we obtain a clear sign restriction from the DSGE model for the uncertainty shock that helps us disentangle it from the level shock. In contrast, the DSGE model is silent on the sign of the tariff rate response unless we impose some specific policy behavior arbitrarily. Restricting the tariff rate reaction to zero would also be problematic as first and second moment shocks often go hand in hand. In other words, with the specification of the SVAR in terms of customs duties we do not have to take a stance on the policy rule for the tariff rate.

We sharpen inference by additionally identifying domestic demand and supply shocks, following the argument of Canova and Paustian (2011). In this way, we also ensure that we disentangle the two trade policy shocks from other drivers of the US business cycle. We obtain the signs for the demand and supply shocks from the prior-predictions of the DSGE model (Figures A.1 and A.2). The sign predictions are robust to parameter uncertainty and in line with standard open economy New Keynesian models (de Walque et al., 2006) and the FED's sigma model (Erceg et al., 2006). Finally, we also inspect the model-implied signs of a news shock about the level of future tariffs, as in Caldara et al. (2020) and Alessandria and Mix (2021). Figure A.3 shows that the signs are different from the ones of the other four types of shocks. We do not identify a news shock as this would raise substantial further econometric challenges (Kilian et al., 2023).

2.2.2 Narrative restrictions

Relying on these traditional sign restrictions yields a set of possible candidate solutions for B_0^{-1}. Narrative sign restrictions that constrain the effects of shocks during historical periods can shrink this set and further sharpen inference. To derive suitable narrative sign restrictions, we draw from the customs duties series and trade policy uncertainty index in Figure 1 and the historical account of US trade policy in Irwin (2017). We use periods of unanticipated major changes in actual tariff levels that are at the same time visible in the customs duties series.[10]

Period	Shock	Sign	Variable	Contribution	Narrative
1971Q3	Tariff	+	Customs duties	largest	Nixon shock
1975Q1	Tariff	+	Customs duties	largest	Ford shock
2008Q4 - 2009Q1	Tariff		Imports	smallest	Great Recession
2018Q1	Tariff	+	Customs duties	largest	Steel and aluminum tariffs
1971Q3	TPU	+	TPU	largest	Nixon shock
1975Q1	TPU	+	TPU	largest	Ford shock
2018Q1	TPU	+			Trump shock

Table 2: Narrative sign restrictions. *Notes:* The table shows the narrative sign restrictions on the shocks and on the historical decomposition of the variables in the Bayesian SVAR in (2) used to identify shocks to the level of tariffs and to trade policy uncertainty (TPU). The sign entry + means a positive shock in that period and variable names denote the variable to which the shock contributes most (largest) or least (smallest) in that period.

Table 2 summarizes the narrative restrictions. In 1971Q3, president Nixon imposed a 10% tariff surcharge on all dutiable imports, dubbed the 'Nixon shock' by historians (Irwin, 2013). President Ford induced a second unanticipated shock in 1975Q1, when he announced and implemented higher taxes on oil imports. This happened a few weeks after Congress had voted on the 1974 Trade Act that was intended to liberalize trade. Moreover, we use President Trump's steel and aluminum tariffs enacted in 2018Q1. The tariffs were announced and implemented within the same quarter and retaliative actions were exercised only in the following quarters. For these episodes, we specify a positive sign of the tariff policy shock and assume that it is the most important driver of customs duties. In contrast, governments refrained from increasing tariffs during the Great Recession, being

[10]Anticipation of tariff policy is an important concern as anticipated changes in taxes may have different effects than unanticipated changes (compare Figures 2 and A.3). Therefore, we choose only narrative episodes where announcement and implementation fall within the same quarter.

aware of the adverse consequences of the Smoot-Hawley tariffs during the Great Depression (Bown and Crowley, 2013). We define a fourth narrative sign restriction that restricts the tariff shock to be the least important driver of imports in 2008Q4-2009Q1.

Concerning the trade policy uncertainty shocks, we place corresponding restrictions for the Nixon and Ford shocks, as trade policy uncertainty spiked considerable during these quarters. Moreover, we assume a positive trade policy uncertainty shock in 2018Q1 when uncertainty about tariffs on washing machines, solar panels, steel and aluminum surged. Section C.3.1 in the appendix shows that this minimal set of narrative restrictions is crucial to disentangle level and uncertainty shocks.

2.3 Estimation

Estimation and inference are Bayesian and follow Antolín-Díaz and Rubio-Ramírez (2018) and Giannone et al. (2015). We use a Minnesota prior with estimated hyperpriors (Giannone et al., 2015) in combination with a sum-of-coefficients prior (Doan et al., 1984) and a dummy-initial-observation prior (Sims, 1993). Identification via sign restrictions does not yield point estimates but sets of possible parameter intervals for the elements in B_0^{-1}. We obtain 1000 admissible draws. These are also used for inference, that is, they yield an indication of the uncertainty around the pointwise median estimates. We report point-wise median and percentiles of impulse responses, as it is common in the literature.[11]

3 The macroeconomic effects of US trade policy

In this section, we present the estimated tariff and trade policy uncertainty shocks as well as their impulse responses. Then, we gauge the importance of both shocks for the US business cycle and

[11] The literature has made substantial recent progress on inference in Bayesian models, which is important to take into account when interpreting the results. First, Baumeister and Hamilton (2015, 2020) and Watson (2019) remark that readers are used to associating error bands with sampling uncertainty, but in large-sample sign-restricted SVARs these error bands only result from the prior for the rotation matrix Q, not sampling uncertainty. Inoue and Kilian (2020) point out that the share of uncertainty resulting from the prior on Q tends to be rather small in most applications, in particular, when assuming several sign restrictions. Our results are not based on a large sample and we use a large number of different sign restrictions. In this case, the inference summarizes both prior uncertainty and sampling uncertainty. We report the full set of impulse responses in Figure A.6 to provide another sense of the uncertainty around the estimates.

estimate their sectoral and spatial effects. Finally, we perform a structural scenario analysis to quantify the output gains of reversing the protectionist measures since 2016.

3.1 Estimated tariff shocks and trade policy uncertainty shocks

Before we quantify the macroeconomic effects of tariff shocks and trade policy uncertainty shocks, we discuss the two estimated shock series to develop a notion about the historical US trade policy events that the shocks capture. The two upper panels of Figure 3 plot the median tariff shocks and the their cumulative version. The largest spikes occur in 1971, 1975, and 2018/19. These are the periods with the largest changes in tariffs and tariff revenues and we have specified narrative sign restrictions around them. There are two large drops in the first quarter of 1972 and 1976, respectively. The tariffs under Nixon and Ford were quickly withdrawn such that tariffs reached their prior levels, captured as two large negative shocks. The third largest positive spike in the series takes place in 2018 when the US increased tariffs mainly on Chinese goods.

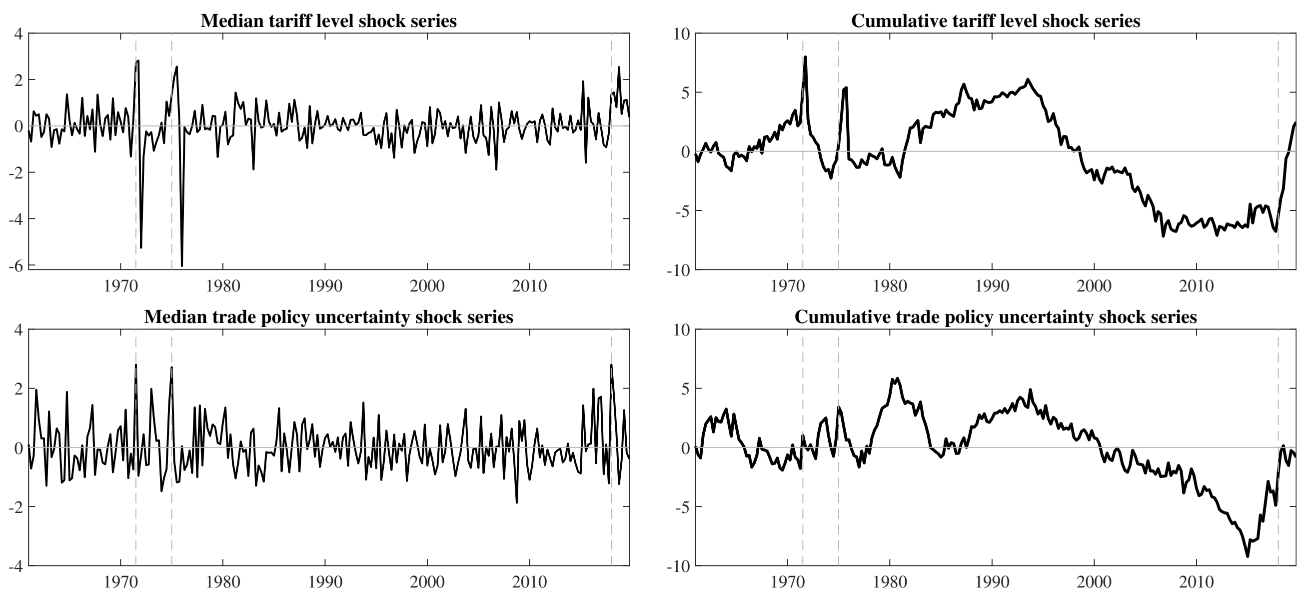


Figure 3: Estimated tariff level shocks and trade policy uncertainty shocks. *Notes:* The figure shows the estimated median shocks to the tariff level and to trade policy uncertainty (left panels) and their cumulative versions (right panels). Grey dotted vertical lines show periods of Nixon, Ford, and Trump shocks.

The cumulative series displays a sequence of tariff reduction shocks in the mid-1970s. Through the mid-1990s, we estimate a series of protectionist shocks. Then, cumulative tariff level shocks fall again until the second half of the 2000s. The first major trade policy event in the sample is the sixth round of multilateral trade negotiations by the members of the General Agreement on Tariffs and Trade (GATT), known as the Kennedy Round, which was concluded in 1967.[12] As a consequence, US average tariffs on dutiable imports decreased from 14% in 1967 to about 6% by 1975 (Irwin, 2017). The cumulative shock series shows consecutive drops until the mid-1970s.

Notwithstanding the conclusion of the Tokyo Round in 1979, the share of imports that was covered by some type of trade restrictions increased from 12% to 21% from 1980 to 1984 (Irwin, 2017) and the shock series rises in the early 1980s. The US increased, for instance, tariffs on Japanese trucks in 1980 and on motorcycles in 1983 (Feenstra, 1989). Quotas in various industries like steel and textiles constituted a major element of US trade policy during this period. Another increase in tariffs was enacted in 1987 on computers, televisions, and power tools from Japan (Irwin, 2017); the series displays a notable uptick.

Shortly afterwards, trade policy became less restrictive. In 1988, the Canada–United States Free Trade Agreement (CUSFTA) was signed, and in 1993 the North American Free Trade Agreement (NAFTA) with Canada and Mexico was approved by Congress, which superseded the CUSFTA. The GATT Uruguay Round came into effect in 1995 and established the WTO. This led to a reduction in tariffs and non-tariff barriers over a horizon of ten years, reflected in a long series of free-trade shocks. In 2000, the US established permanent normal trade relations with China, which led to China's WTO accession. From 2002 to 2007 the US concluded several free trade agreements but the next round of GATT negotiations, the Doha round, failed and was put to rest in 2015. During the Great Recession in 2008/09, there was no major increase in tariffs except that the Obama administration levied duties on car and truck tires from China (Irwin, 2017). The final major rise in the shock series is related to the tariffs implemented by the Trump administration on steel and aluminum and on imports from China in 2018/19.

The estimated trade policy uncertainty shocks partially mirror these developments. However, the largest shocks typically occur a few quarters before the tariff level shocks spike, indicating that uncertainty often rises before tariffs actually change. This is visible in the quarters preceding the 2018-20 US-China trade dispute. The cumulative uncertainty shocks rise more than a year before the cumulative level series. Figure A.8 corroborates the narrative inspection of the two

[12] Prior to the Kennedy Round, the 25% 'chicken tax' on trucks imported from Europe and imposed by President Johnson in 1964 is a tariff that is still active today (Lawrence, 2009).

shock series formally. It shows by means of historical decompositions that the model successfully disentangles the two dimensions of US trade policy: level shocks are much more important for the dynamics of customs duties than uncertainty shocks and uncertainty shocks are more relevant for the time-variation in the trade policy uncertainty index than level shocks.

3.2 Dynamic effects and trade elasticity

Figure 4 presents the macroeconomic effects of a tariff level shock over a horizon of 32 quarters in the top panels. The solid lines show the point-wise median estimates and the shaded areas the 68% highest posterior density credible sets.[13] A one standard deviation shock raises customs duties by about 5% on impact, which constitutes a 0.2% points increase of the average tariff rate of 3.6% over the sample. Thereafter, duties fall slowly. It takes more than eight years for them to return to trend. Imports drop strongly on impact, by 1%, and decrease further to –1.5% in the second quarter. They remain below the level where they would have been without the shock after eight years. The response of exports is similar to the response of imports, but slightly smaller and less persistent. GDP falls immediately and credibly different from zero by 0.2% and stays at this level for eight years. The exchange rate appreciates by a little less than 0.5% upon impact, and by slightly more over time. The consumer price level rise marginally upon impact and then shows a tendency to rise further. But the sets are wide and cover zero after the initial period. The price response is also not robust as the sensitivity analysis shows. The trade policy uncertainty index increases, reflecting that changes in tariffs are often associated with increased uncertainty about trade policy. In addition, the increase might occur mechanically as the uncertainty index is constructed by counting words related to trade policy and uncertainty. Overall, the exogenous increase in tariffs has persistently adverse macroeconomic effects. International trade drops strongly and output is negatively affected.

The bottom panels show the effects of a positive trade policy uncertainty shock of one standard deviation. The uncertainty index increases by 16% on impact. Imports fall by about 1%. They remain below trend for the full horizon but the effect is not distinguishable from zero after the first quarters. Customs duties fall upon impact. Then, they overshoot, mirroring that increases in

[13] Figure A.6 shows the responses for all 1000 draws. Figure A.7 shows the estimated responses to domestic demand and supply shocks.

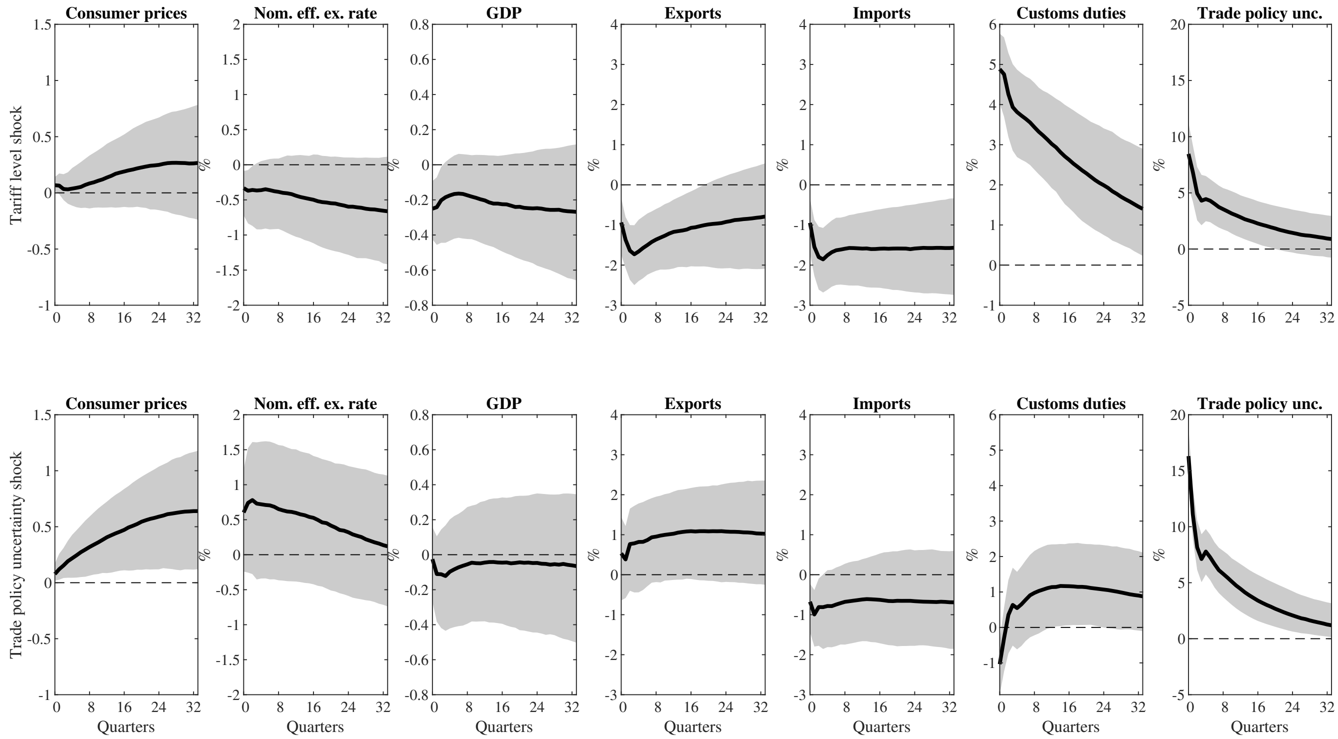


Figure 4: Estimated responses to tariff level shock and trade policy uncertainty shock. *Notes:* The figure presents the macroeconomic effects of a shock of one standard deviation to tariffs in the upper panels and to trade policy uncertainty in the lower panels over a horizon of 32 quarters in the US. The solid lines show the point-wise median estimates and the shaded areas the 68% highest posterior density credible sets. An increase in the nominal effective exchange rate is a US-Dollar depreciation.

trade policy uncertainty often precede actual tariff changes. The nominal exchange rate tends to depreciate. Consistently, exports increase tentatively. Higher trade policy uncertainty is slightly contractionary for output but the effect is imprecisely estimated. Consumer prices increase strongly and persistently by up to 0.6%. The credible sets exclude zero over the full horizon. Overall, trade policy uncertainty shocks have notably negative effects on imports and are inflationary, while their output effects are moderate.[14]

From the responses to the tariff level shock we compute two measures of the general equilibrium import elasticity. For the first, $\eta_{\tau,h} = (\Theta_h)_{\tau,imports}/(\Theta_h)_{\tau,duties}$, we divide the response of imports $(\Theta_h)_{\tau,imports}$ by the response of customs duties $(\Theta_h)_{\tau,duties}$ for each horizon h.[15] This gives the

[14] As we rely on a news-based measure of trade policy uncertainty, we estimate the average effect of unexpected innovations to this series which picks up changes in uncertainty about both liberalization and more restrictive trade policy which might attenuate the average estimated impact.

[15] The responses of the endogenous variables to the structural shocks in the SVAR in (2) are traced over time via $\Theta_h = \theta_h B_0^{-1}$ for $h = 1, 2, ...$, where Θ_h is an n x n matrix of the structural impulse responses for the horizon h with $\theta_h = \sum_{j=1}^{h} \theta_{h-j} A_j$ and $\theta_0 = I_n$.

dynamic path of the percentage decline in imports induced by one percent higher tariff revenues. The left panel of Figure 5 shows the result. The median import elasticity $\eta_{\tau,h}$ is –0.2 upon impact, falls to –0.5 after one year, and to –0.7 after six years. The values are different from zero according to the credible sets. The eight-year import elasticity is –0.8. The estimation uncertainty increases considerably with the horizon as the denominator in the response ratio converges to zero, which inflates the variability of the ratio.

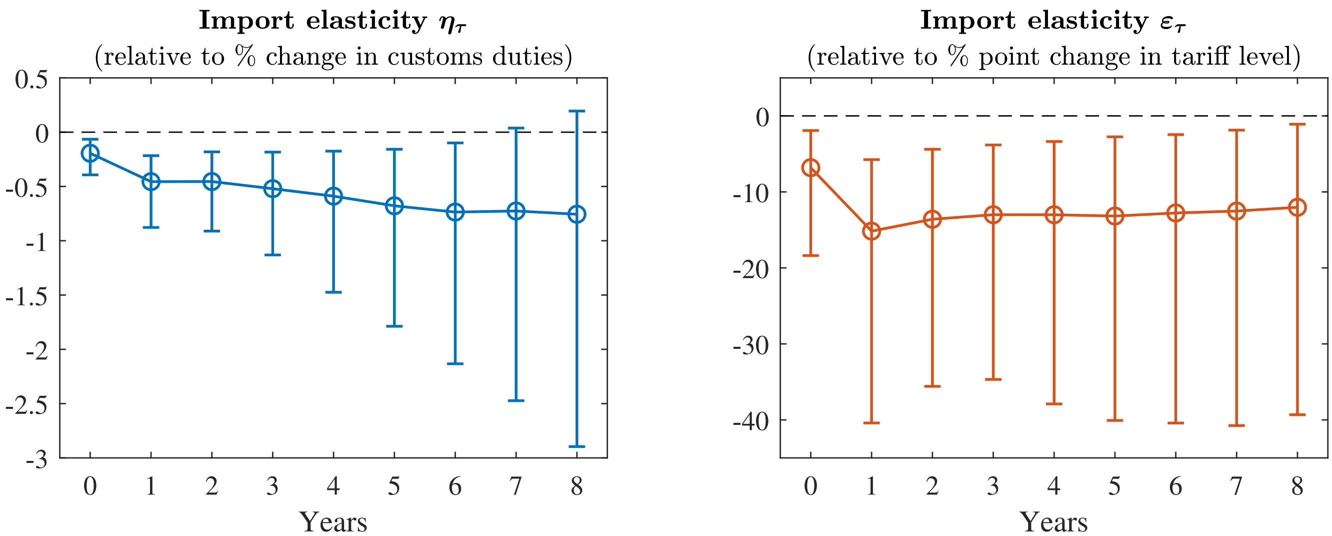


Figure 5: Estimated elasticities of imports to customs duties and the tariff level. *Notes:* The left panel displays $\eta_{\tau,h}$, the responses from Figure 4 of imports relative to the response of customs duties at the same horizon following a tariff level shock. The right panel displays $\varepsilon_{\tau,h}$, the response of imports relative to a percentage point increase in the average effective tariff following a tariff level shock. Median estimates and 68% confidence bands are based on the individual model draws.

The right panel presents a second measure of the import elasticity that is more closely related to the way in which import elasticities are typically measured in microeconomic studies. We compute $\varepsilon_{\tau,h} = (\Theta_h)_{\tau,imports}/(\Delta_h \text{Tariff})_\tau$ from the responses of customs duties and imports to the tariff level shock. The implied percentage point increase in the tariff rate on impact $(\Delta\text{Tariff})_\tau$ is calculated as $3.56\% \times 1.05/0.99 - 3.56\% = 3.78\% - 3.56\% = 0.22\%$ points, where 3.56% is the average effective tariff rate in the sample and 1.05 and 0.99 are the impact responses of customs duties and imports relative to trend, respectively. Then, we divide the response of imports by 0.22 to obtain the general equilibrium import elasticity to a 1% point increase in the effective tariff rate. The contemporaneous elasticity is –7. The dynamic elasticity drops to –15, before converging to its long run value of –12. The credible sets exclude zero at all horizons but imply considerable uncertainty.

The median values are large (in absolute value). They are at the upper bound of the range of available microeconomic estimates. Head and Mayer (2014) summarize 32 articles and report a median and mean value of –5 and –7, respectively, with a standard deviation of 9. Hillberry and Hummels (2013) survey the literature and report an even wider range, going from –1 to –35. Alessandria et al. (2025c) provide recent estimates specifically for the US using annual product-country level data. The authors obtain values of around –4 in the short run and –10 in the long run. Using macroeconomic data for the US, Alessandria et al. (2025b) obtain long run values exceeding (in absolute value) –20.

Next, Figure 6 paints a broader picture of the effects of both shocks by showing the responses of further variables. We re-estimate model (2) using the same identifying restrictions as before, but we either replace output by one of its components or we add additional variables to the model one at a time. We leave the responses of the alternative variables unrestricted.

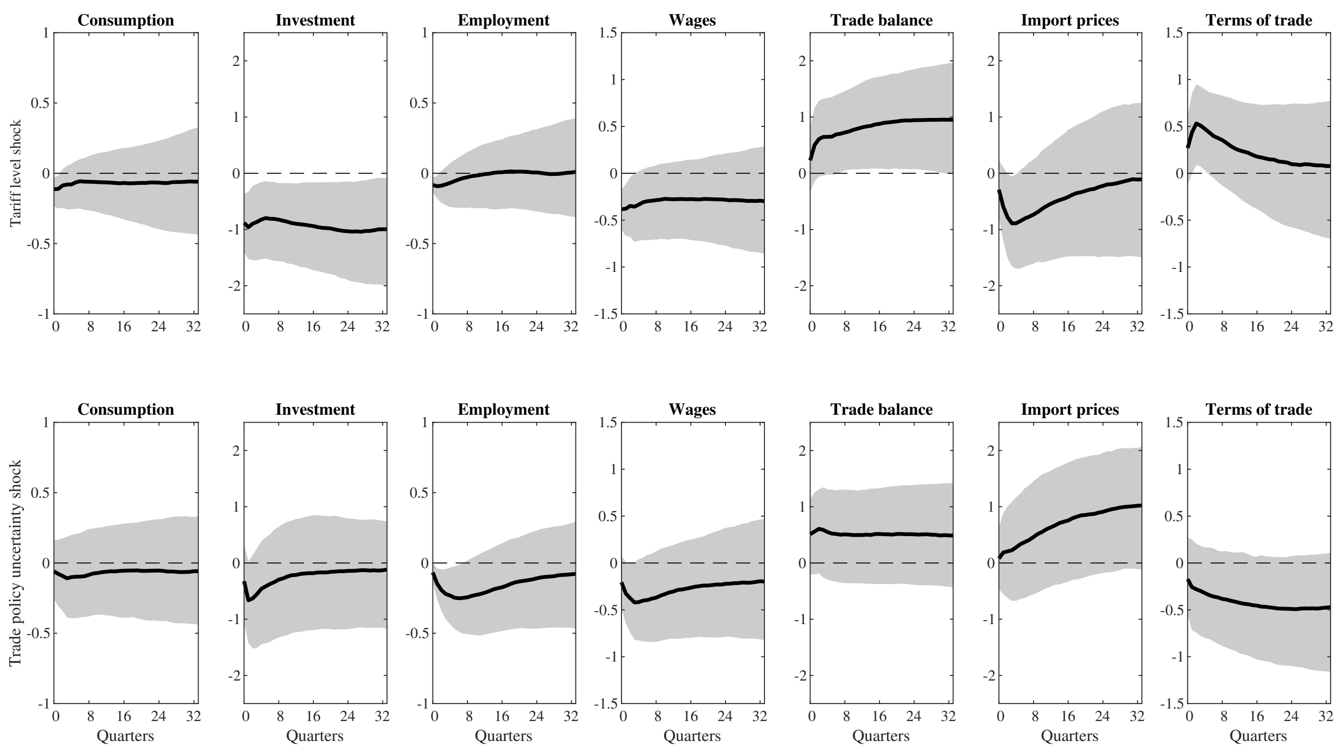


Figure 6: Responses of other variables to tariff level and trade policy uncertainty shock. *Notes:* The top panels show the effects of a positive tariff level shock of one standard deviation on consumption, investment, employment, wages, the trade balance (net exports as % of GDP), import prices, and the terms of trade (export/import prices) over 32 quarters. The solid line shows point-wise median impulse responses and the shaded areas 68% highest posterior density credible sets. The lower panels show the effect of a positive trade policy uncertainty shock of one standard deviation.

The top panels show the effects of tariff level shocks. Domestic consumption declines persistently but the effect is small and credibly different from zero only for a few quarters. In contrast, investment drops strongly, by 1%, and with high probability. It remains persistently below trend for more than eight years. The strong negative effect on investment is in line with specific microeconomic evidence for the US-China trade war that documents a corresponding substantial decline in investment growth rates of listed US companies (Amiti et al., 2020). Employment falls marginally on impact and then reverts. The small negative effect on employment complements the microeconomic evidence on the effects of China's WTO accession with macroeconomic evidence. Autor et al. (2013, 2016) find that the partial equilibrium effects of this specific free-trade event are negative for local US labor markets with industries strongly exposed to foreign competitors. Our evidence suggests that the general equilibrium effect of shifts toward free trade in the US since the 1960s are on average slightly positive for total US employment. Higher tariffs also lead to a persistent decline in wages by 0.4%. The decline is consistent with a reduced marginal product of labor due to lower investment and, together with the small decline in employment, indicates a reduced demand for labor.

The trade balance increases by 0.5-1% points of GDP, and the credible sets exclude zero for many years, as imports drop more than exports. The increasing trade balance implies capital outflows that are in line with the strong negative domestic investment response. Import prices decline by up to -1% at trough and have returned to trend after eight years. The response is imprecisely estimated but indicates incomplete pass-through of higher tariffs.

This finding complements a large body of partial equilibrium microeconomic evidence that documents incomplete pass-through for highly disaggregated trade data (Fajgelbaum and Khandelwal, 2022) with a general equilibrium estimate. The negative response means that, on average since the 1960s, the US affects the terms of trade in its favor by using tariffs. Consistently, we see that the terms of trade improve by up to 0.5% a few quarters after the shock, and the dynamic closely mirrors that of import prices.

The bottom row shows the effects of a positive trade policy uncertainty shock on the same variables. Consumption shows a small negative but imprecisely estimated response. Investment, employment, and wages all fall more notably but the estimation uncertainty is high. For employment, the decline is marginally distinguishable from zero. The investment response is qualitatively and quantitatively similar to the estimate of Caldara et al. (2020). The trade balance tends to improve, import prices to rise, and the terms of trade to decline. But again all effects are estimated with considerable uncertainty.

Finally, comparing the empirical responses in Figures 4 and 6 to the prior-predictions of Figure 2 shows that the effects tend to be larger in the data than in the DSGE model even after multiplying the latter with 5 to account for the larger empirical shock size. At least two reasons could explain the discrepancy. First, the calibration and prior distributions could imply low effects and alternative choices would increase the effects of the shocks. Second, the model contains no endogenous persistence or amplification mechanisms. One potential candidate for such a mechanism would be more trade in intermediate goods. While the model features trade in intermediate consumption goods, it does not have capital and/ or trade in intermediate capital goods. Indeed, Figure 6 suggests an important role for capital formation as investment falls in response to both types of shocks. We do not attempt to go back and model this theoretically as the investment response is a posterior outcome of the empirical analysis based on the prior-predictive analysis of the chosen model and we do not want to let the posteriors inform the priors. Instead, we leave the inclusion of endogenous amplification mechanisms for future research, for example, along the lines of Alessandria and Mix (2021) or Alessandria et al. (2025b) who highlight the importance of endogenous physical capital formation for dynamic trade models.

3.3 Macroeconomic relevance

After estimating the dynamic effects of the two shocks, we now quantify their macroeconomic importance. First, we compute the average importance in the sample by means of a forecast error variance decomposition. Figure 7 shows the fraction of the unexpected variability of the endogenous variables of the baseline specification due to tariff level shocks over 32 quarters in the upper panels. Tariff level shocks explain half of the impact variability in customs duties. This high number documents an important role for exogenous policy changes. The endogenous response of tariff proceeds to business cycle shocks accounts for the other half of the variability. It is important to recall that domestic demand and supply shocks entail fundamentally different effects on customs duties and imports (driving both in the same direction) than tariff level shocks (driving both in opposite directions). This means that the risk of confounding exogenous policy shifts with endogenous revenue responses when using customs duties is minimal. The tariff shocks are also relevant for the variation in exports and imports, contributing 10-15%, depending on the horizon. The explanatory power for fluctuations in the nominal exchange rate and consumer prices is lower. It increases up to 5% in the eighth year. Given the importance for import and export fluctuations, the shocks also drive US output. The contribution is 10% initially and 5% in the medium run.

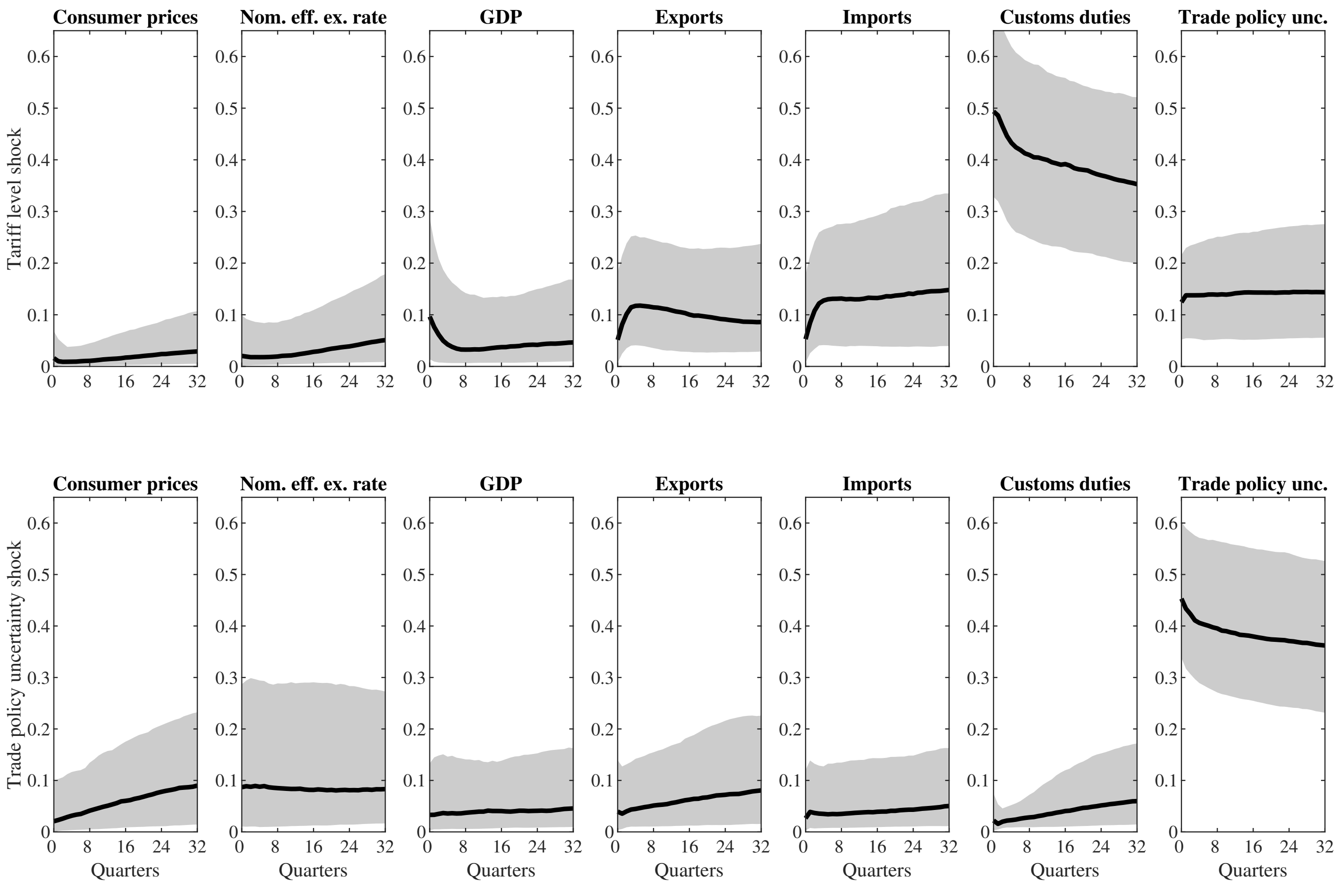


Figure 7: Forecast error variance decomposition. *Notes:* The figure shows the percentage of the forecast error variance of the endogenous variables (in columns) due to tariff level shocks in the upper panels and due to trade policy uncertainty shocks in the lower panels over a horizon of 32 quarters in the US. The solid lines show the point-wise median estimates and the shaded areas the 68% highest posterior density credible sets.

The bottom panels show the contribution of trade policy uncertainty shocks. Their relevance is lower than that of the level shocks for imports and exports but higher for consumer prices and the nominal exchange rate. Uncertainty shocks explain around 5% of the unexpected volatility in imports and exports, and up to 10% of the variability in consumer prices and the exchange rate. Their contribution to the variation in output is about 5%. They are less relevant for GDP in the short run compared to tariff shocks but similar to those in the medium run. As they affect imports, they also drive customs duties. But the impact explanation is negligible, suggesting that the identified exogenous variation in the uncertainty index is not due to tariff changes. Instead, the uncertainty shocks account for nearly half of the impact variation in the uncertainty index. This number indicates that recursive identification strategies, which assume that trade policy uncertainty is exogenous, may lead to biased results as half of the variation in the measure is an endogenous response to other shocks. Taken together, the numbers suggest that level and uncertainty shocks are both relevant drivers of prices and quantities, with uncertainty shocks slightly more relevant for prices and level shocks for quantities.

The average relevance of the two shocks may mask that their importance changes over time. To capture this variation, we compute historical decompositions in Figure 8. The solid lines show the model-consistent output, employment and investment gap, and the trade balance/GDP. The blue bars show the contribution of the tariff level shocks (left) and the trade policy uncertainty shocks (right) to these variables. Until the mid-1980s, tariff shocks contribute little to GDP and employment fluctuations. Visible exceptions are the Nixon and Ford tariff episodes in 1971 and 1974. Investment and the trade balance are more exposed to the shocks even in this early period. The Nixon and Ford events lowered investment and improved the trade balance, but only shortly.

Since the mid-1980s, tariff shocks are an important driver of all variables except employment. First, the trade tensions with Japan, among others, lowered GDP and investment, whereas they raised the trade balance until the mid-1990s. Thereafter, the trade liberalization related to CUS-FTA/NAFTA in 1989/1994, the creation of the WTO in 1995, and the accession of China to the WTO in 2001 generated long output and investment booms. The estimates suggest that the shift to lower tariffs raised output and investment by up to 3 and 5 log points, respectively, for nearly 20 years. The boom came to an end with the return to protectionism in 2016. The flip side of the free trade shocks and the increased capital demand was a persistent widening of the trade balance since the mid-1990s. But the tariff shocks account for a relatively small fraction of the overall deficit, suggesting that other more dominant forces were at play as well.

The estimates paint a more favorable picture of the implications of China's WTO accession for the US than the influential work of Autor et al. (2013, 2016). The authors find that following this event wages and employment fell significantly in local US labor markets which were most exposed to import competition from China. We find that the general equilibrium effects of the shift toward

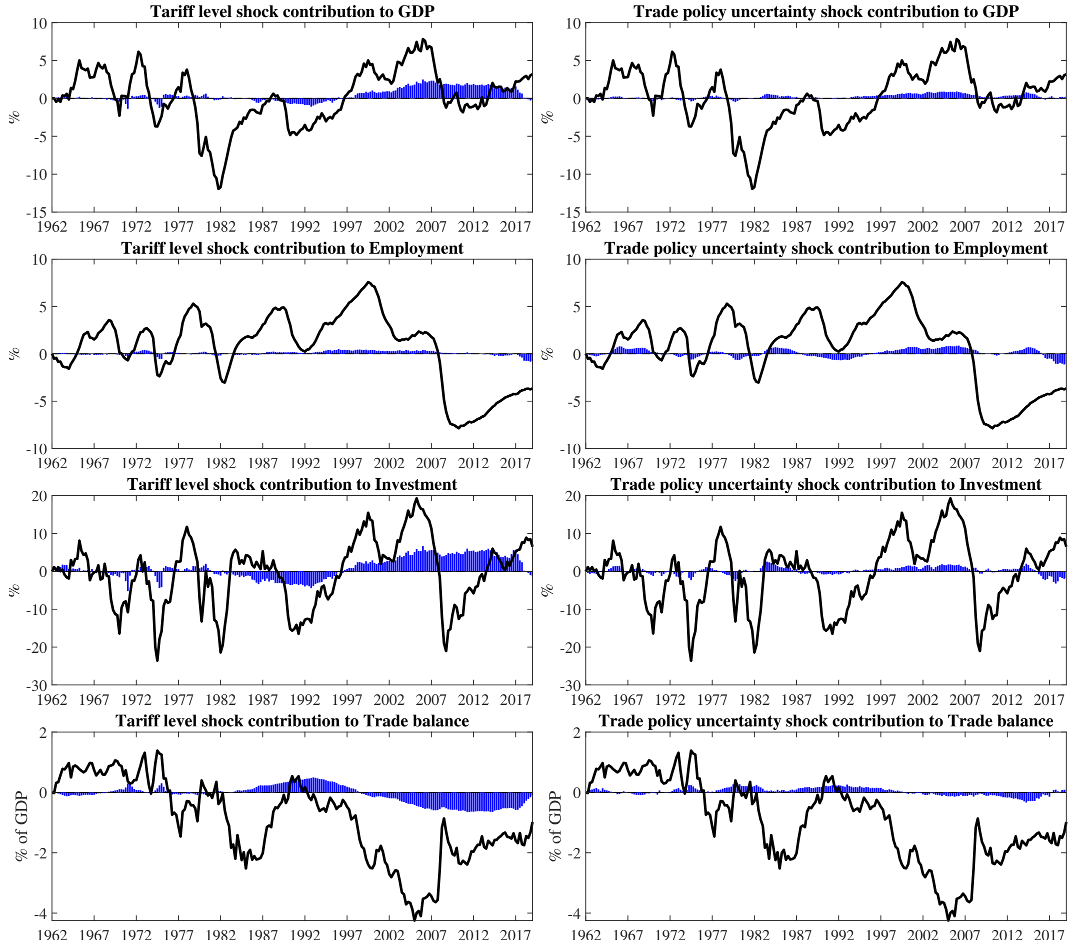


Figure 8: Historical decomposition of GDP, employment, investment and trade balance. *Notes:* The black lines show detrended data and the blue bars show the historical contribution of tariff level shocks (left panels) and of trade policy uncertainty shocks (right panels) to GDP, employment, investment and the trade balance. The trade balance is defined as net exports relative to GDP and is added in growth rates as an additional variable to the baseline model.

free trade in the 1990s and 2000s had small effects on total employment in the US, suggesting that the negative partial equilibrium estimates tend to wash out in general equilibrium, possibly because of aggregate wage changes in both the US and China. In addition, we find a strong positive response of investment during and following that event. The overall effect on GDP was positive.

The contributions of the trade policy uncertainty shocks largely mimic those of the tariff level shocks but are typically slightly smaller. Until the mid-1980s, the contributions fluctuate up and down for all variables. The back and forth of the trade relations with Japan in the 1980s and the NAFTA/GATT negotiations increased uncertainty and, hence, the trade balance. Since the 1990s, lower trade policy uncertainty persistently raised output, investment, and employment, whereas it lowered the trade balance. The employment contributions are more visible than for the level shocks, consistent with the stronger response of employment to uncertainty than to level shocks (Figure 4).

We also use the historical decomposition to assess the output effects of the return to protectionism in 2016. For this, we compute the contribution of tariff level and uncertainty shocks to GDP over the period 2017Q1-2019Q4. Appendix Figure A.9 zooms into this episode. In 2017, the contributions of lingering easing tariff level shocks are slightly positive, raising GDP by 0.2%. The sharp turn toward protectionism manifests itself in the tariff level shocks in the years 2018 and 2019. The output costs are 1.2% and a further 0.3% in 2019, yielding a cumulative fall in output below trend from 2017Q4 to 2019Q4 of 1.6%. Higher trade policy uncertainty shocks add to this. Higher uncertainty contributed negatively to GDP already in 2016, leaving GDP 0.3% below trend after the period 2016Q1 to 2019Q4.

These estimated costs of the tariff increases are similar in size as the estimates of Hoang and Mix (2024) who build a dynamic general equilibrium trade model with physical capital formation and firm dynamics. The authors stress the importance of the endogenous investment response for their results. The costs are an order of magnitude higher than the partial equilibrium estimate for the tariff level increases in 2017/18 of Amiti et al. (2019), or the estimate of Fajgelbaum et al. (2019) based on a general equilibrium but static trade model with fixed capital and without trade policy uncertainty. Our estimated impulse responses suggest that this difference could be due to the strong negative general equilibrium response of investment to protectionist shocks.

3.4 Sectoral and regional effects

We complement the aggregate results with sectoral and regional analyses. We project disaggregated data on the estimated tariff level and trade policy uncertainty shocks from Figure 3, using the following regressions:

$$y^i_{t+h} = \alpha^i_h + (\beta^i_h)\prime X^i_{j,t:t-1} + \varphi^i_h Shock_{j,t} + \xi^i_{t+h} \quad \text{for} \quad h = 0, \ldots, H, \tag{4}$$

where y^i_{t+h} is the sectoral or regional outcome variable of interest, α^i_h is an intercept, $x^i_{j,t:t-1}$ is a vector of controls, $Shock_{j,t} = \hat{\varepsilon}_{j,t}$ is the tariff level or trade policy uncertainty shock, and ξ^i_{t+h} is an error term for outcome variable i at horizon h. φ_h^i is the impulse response estimate of the outcome variable i to shock j at horizon h. $x_{j,t:t-1}^i$ includes one lag of the outcome variable i and the contemporaneous other trade shock given the two trade shocks' mildly positive correlation.[16] We estimate (4) for each posterior estimate of the shock series $\hat{\varepsilon}_{j,t}$ and compute 68% point-wise credible sets of the impulse responses. Using the median estimated shock series and frequentist confidence bands yields similar results. Throughout the section, we focus on the peak/trough responses over a three-year horizon. The full set of underlying responses is in Appendix C.2.

Figure 9 contains the sectoral responses to a unit positive tariff shock. It reports the absolute maximum responses of imports, exports, investment, and employment for each sector, ordered by size. All but one sectors reduce imports and the effects are credibly different from zero. With two exceptions, the effects are between –5% and –1%. The picture for exports is similar. All but three sectors export less and the decline is distinguishable from zero for all of these. The magnitude of the effects is also similar to the one on imports. For investment, the pattern is again similar. 11 out of 19 sectors cut back on capital formation and the effect is often different from zero with high probability. A few sectors increase investment, suggesting some redistribution of economic activity. Employment declines in seven sectors and tends to increases in four. While the declines are mostly distinguishable from zero, the increases are estimated with high uncertainty. Nevertheless, the more ambiguous employment effects compared to the relatively homogeneous pictures for the other three variables might explain why in aggregate employment shows only a mild contraction, while US international trade and domestic investment fall strongly.

Figure 10 shows the absolute maximum responses to a unit positive trade policy uncertainty shock. Qualitatively, the results for imports, investment, and employment are similar to the findings for the level shock but different for exports. Quantitatively, the sector effects of the uncertainty shocks tend to be slightly smaller than the impacts of the level shocks. Imports drop in 12 sectors and increase only in 5. Investment and employment decline in all but one sectors. The trough import and investment responses are often discernibly different from zero, while the employment effects are not. In sharp contrast, exports increase in all but one sector and the increases are often different from zero with high probability. This uniform pattern mirrors the positive aggregate

[16]The results are robust to excluding the contemporaneous other trade shock or including additional lags of the outcome variable, additional lags of the two trade shocks or lags of the VAR variables.

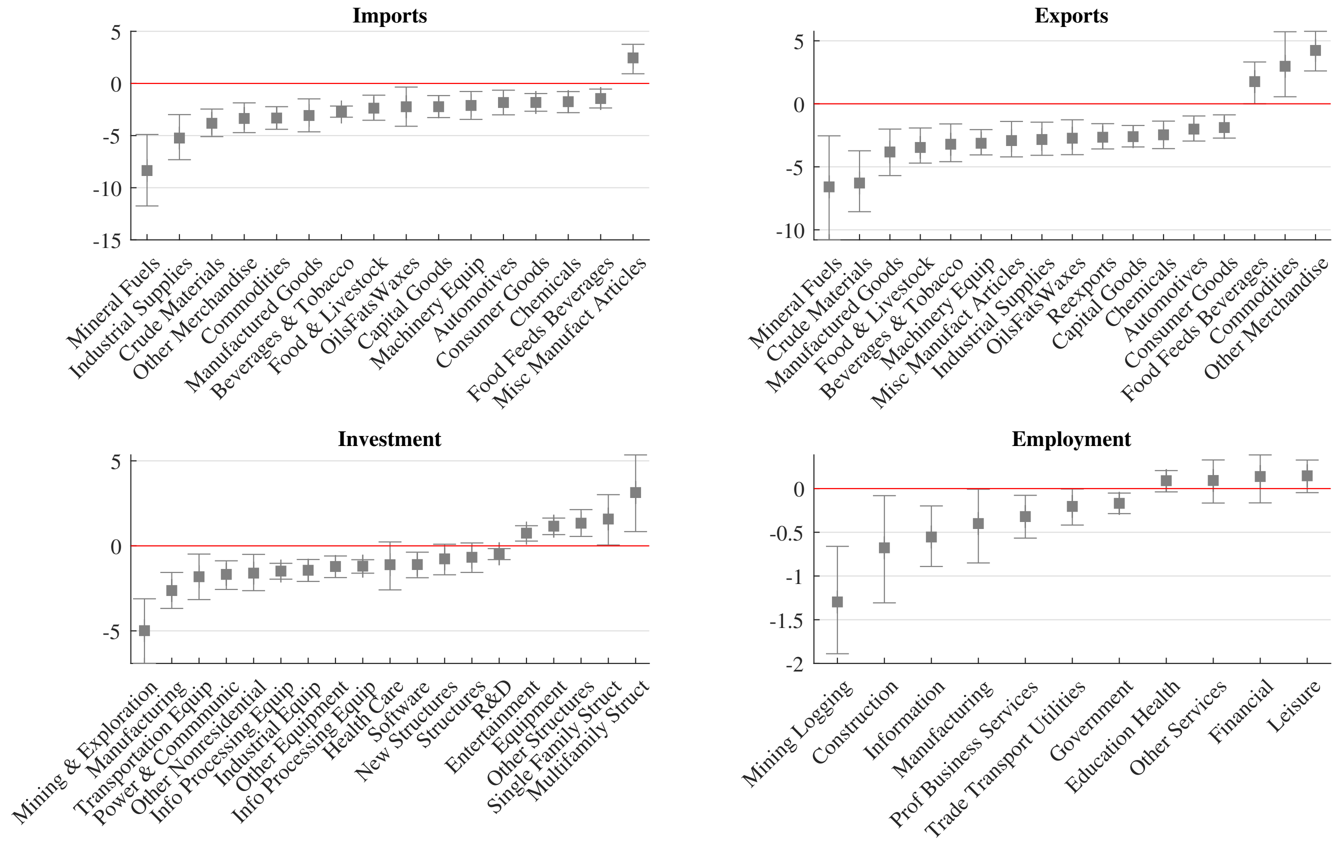


Figure 9: Sectoral resonses to tariff level shocks. *Notes:* The figure shows the absolute maximum response of sectoral imports, exports, investment, and employment to a unit tariff level shock over the first 12 quarters, obtained from local projections. The box is the median response, the lines are the 68% point-wise sets.

response of exports and is in line with the tendency of the currency to depreciate.

Comparing the effects of level and uncertainty shocks indicates that both depress imports and investment across the board and have mostly adverse consequences for sectoral employment. A main difference between the two types of shocks are the effects on exports, which are negative for tariffs and positive for trade policy uncertainty across most sectors.

In Figure 11, we assess the spatial distribution of the effects across US states. Panel (a) shows the peak/trough response of state employment to a unit positive tariff level shock. Greener states indicate more positive peaks, whereas darker red states refer to deeper troughs.[17] Most states are orange to red, which indicates a negative employment reaction. Some states clearly lose jobs (Alaska, Nevada, Oklahoma, West Virginia, Wyoming), while a few states in the East seem to gain some (Georgia, North and South Carolina, Tennessee).

[17] We focus on employment as this is the only quarterly measure of state economic activity that is consistently available since the 1960s.

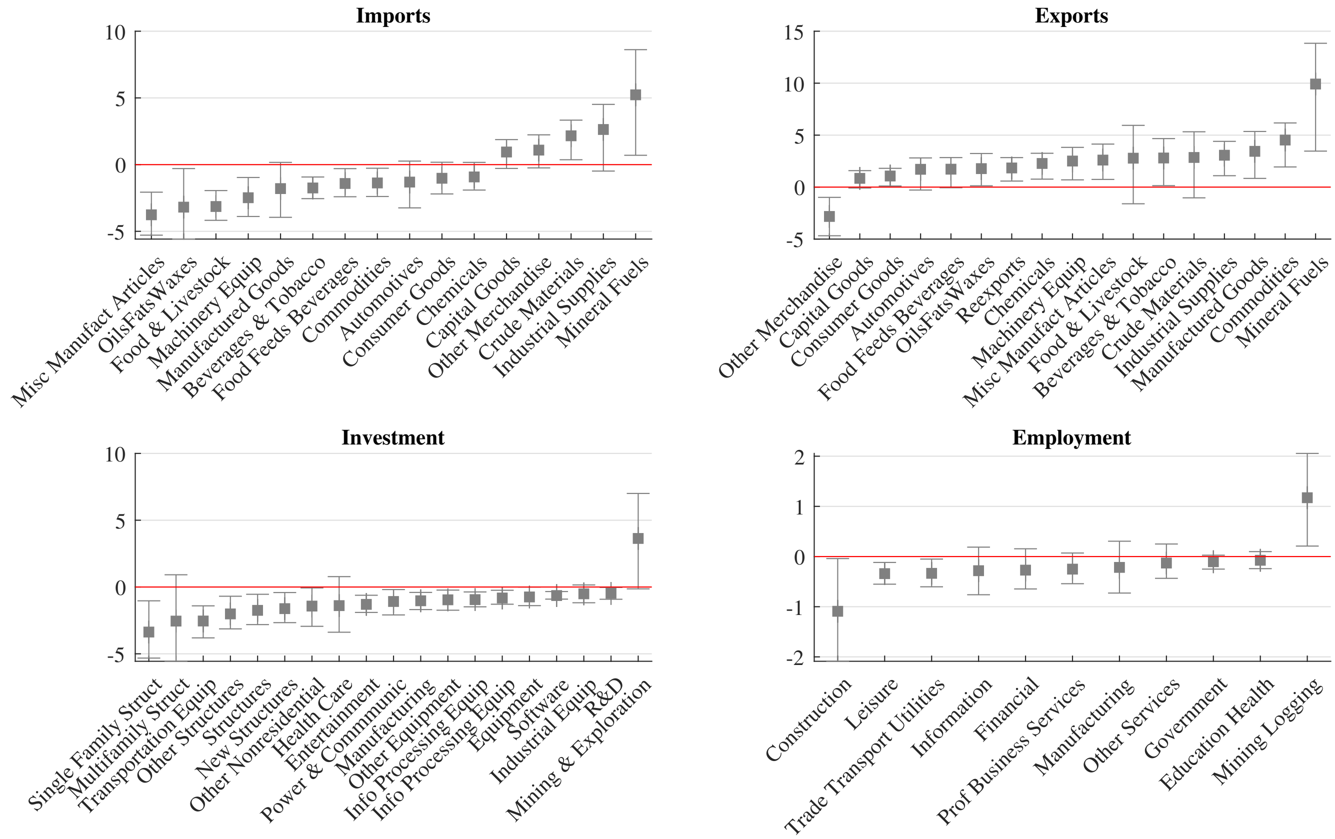
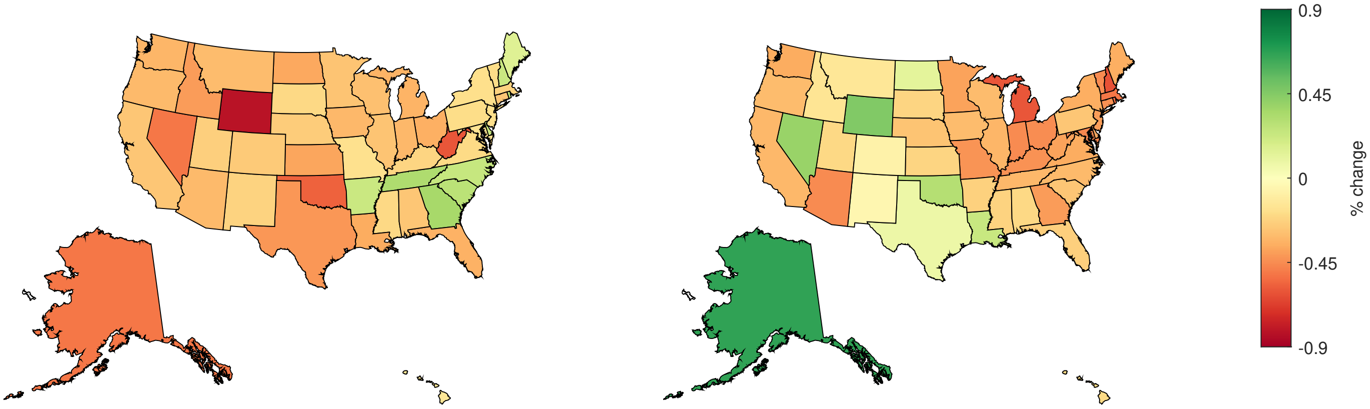


Figure 10: Sectoral resonses to trade policy uncertainty shocks. *Notes:* The figure shows the absolute maximum response of sectoral imports, exports, investment, and employment to a positive unit trade policy uncertainty shock over the first 12 quarters, obtained from local projections. The box is the median, the lines are 68% credible sets.

Panel (b) shows the estimates for a unit trade policy uncertainty shock. The legend is the same so that the magnitude of the effects is directly comparable across panels. The spatial pattern is a bit different than for tariff shocks. The map is predominantly red at the coasts and in the capital intensive Rust Belt. The states in the Middle-West and Alaska are yellow to green. One explanation might be the differential exposure of these states to the exchange rate depreciation. Many produce commodities that are sold at competitive world markets and respond more to US-Dollar fluctuations than differentiated goods like industrial or information technology products. The latter goods also depend more on intermediate inputs and are thus more negatively affected when imports fall. Overall, the findings question the idea that protectionism creates systematically more domestic jobs or allows redistributing them across the country or sectors.



(a) Employment effect of tariff level shock

(b) Employment effect of trade policy uncertainty shock

Figure 11: Peak employment effect across US states. *Notes:* The figure shows the absolute maximum response of state employment to a unit positive tariff level shock in panel (a) and to a unit positive trade policy uncertainty shock in panel (b), obtained from local projections. The colors indicate the sign and size of the effect.

3.5 The output effects of a return to free trade

After having documented the largely adverse effects of higher tariffs and trade policy uncertainty, we ask: what would be the macroeconomic effects if the US was to reverse the tariff and uncertainty increases since 2016. To answer this question, we return to the baseline SVAR model and conduct a structural scenario analysis, following Antolín-Díaz et al. (2021). We assume that customs duties and trade policy uncertainty gradually decrease back to their pre-2016 levels, driven only by tariff level and uncertainty shocks. Technically, we search for two shock series that induce the prespecified paths for customs duties and the trade policy uncertainty index over the period 2020Q1-2022Q4. The required shocks are shown in Figure A.10.

In Figure 12, the scenario paths of customs duties and the uncertainty index are the solid red lines in the first and second panel. The black lines show historical data until 2019Q4. Both variables are restricted to return linearly to their initial levels within three years. We contrast the scenario paths to the unconditional forecasts of the model, in blue. The scenario assumes a quicker return to free trade than the model predicts, in particular for customs duties. For uncertainty, the difference between the scenario and the forecast is small for the first two years but then widens visibly.

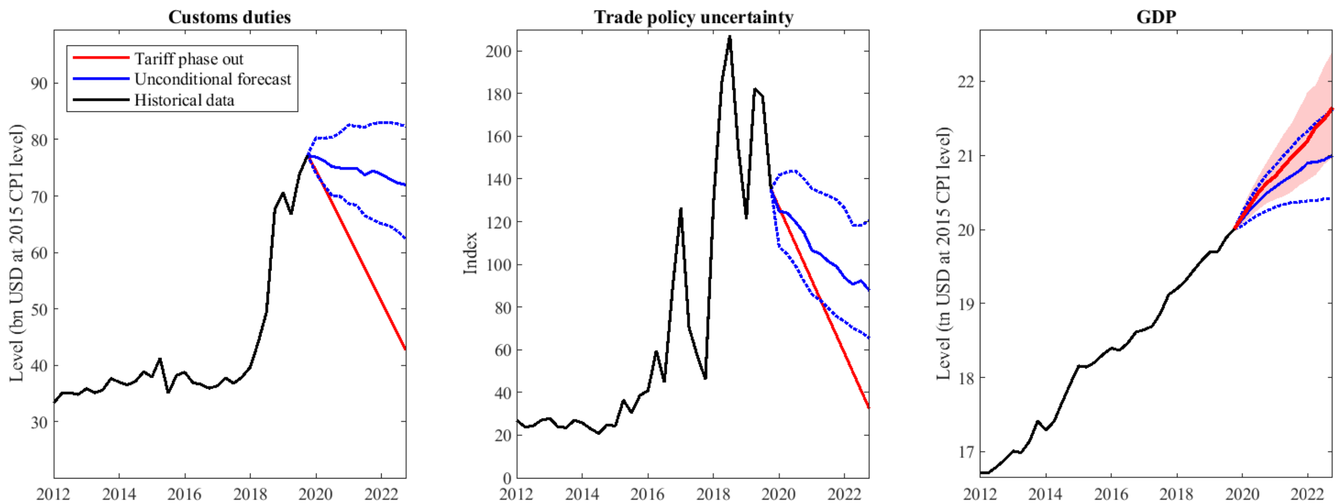


Figure 12: Structural scenario of return to free trade. *Notes:* The red solid line and shaded region in the third panel are the median forecast and 40% point-wise credible sets of GDP for a scenario in which customs duties and trade policy uncertainty revert to pre-2016 levels, shown by the red solid lines in the first two panels. The scenario is driven by tariff level and uncertainty shocks. The blue dotted lines show medians and 40% point-wise credible sets of the unconditional forecasts of the model.

The right panel shows the evolution of GDP, left unrestricted, in both cases. The differing paths result from the alternative stances of trade policy as we constrain the remaining shocks in the system to their unconditional distributions. The GDP increases are similar in the first two quarters after the policy change. Thereafter, the return to free trade generates increasingly higher output than the unconditional forecast. After three years, the difference in median GDP is 3.2%.

4 Sensitivity analysis

We assess the sensitivity of the main results. This section contains a summary thereof. The details are in Appendix C. Overall, the main findings are largely robust to alterations of the endogenous variables, the lag length, and the identifying assumptions. First, we study the impulse responses and variance decompositions when changing the set of narrative restrictions (Section C.3.1). This shows that the baseline set is necessary to distinguish level from volatility shocks, that the output effects are mostly more negative for level than for uncertainty shocks and that trade and price responses are largely robust across specifications. Second, we replace the news-based trade policy uncertainty measure with a realized tariff volatility measure based on a particle filter (Born and Pfeifer, 2014; Fernández-Villaverde et al., 2015; Caldara et al., 2020). The baseline results are qualitatively robust

(Section C.3.2). Third, we compute the responses to tariff level and trade policy uncertainty shocks when changing some of the endogenous variables (Section C.3.3). In Figures A.24-A.26, we replace output with consumption, investment, and employment, respectively. In Figure A.27, we replace the nominal by the real exchange rate. In Figure A.28, we replace the consumer with the producer price index. In Figures A.29 andA.30, we add the trade balance/GDP and the terms of trade. In Figure A.31, we end the sample in 2016Q4, before the Trump administration. In Figure A.32 and A.33, we use two and six lags of the endogenous variables, respectively. In Figure A.34, we add total factor productivity and finally, in A.35, we additionally identify a monetary policy shock.

5 Conclusion

Since 2016 trade policy is again at the center stage of the international economic policy debate. This paper provides evidence that unexpected increases in import tariffs and in trade policy uncertainty have mostly negative consequences for the US economy, and are largely ineffective at redistributing economic activity across sectors or space. We use a canonical two-country DSGE model to derive theory-consistent yet robust sign restrictions, complemented with narrative restrictions, for the identification of tariff shocks and trade policy uncertainty shocks in Bayesian SVARs. We estimate and compare the effects of these two dimensions of US trade policy consistently in one model, providing a macroeconomic account since the 1960s.

Higher tariffs reduce US foreign trade and domestic investment strongly, in aggregate and across most sectors. Greater uncertainty about US trade policy has also negative effects. It weighs particularly on imports and investment. Both first and second moment trade policy shocks improve the trade balance, but at the cost of a domestic demand compression and higher consumer prices. The employment impacts are negative but small. On average, both types of shocks are important for the US economy. They explain 5-10% of the output variability. Historically, the shifts to free trade in the 1990s/2000s induced a two decades lasting investment and output boom while widening the trade deficit. Correspondingly, we estimate that reversing the 2018/19 protectionism would generate an output gain of 3% after three years. While policy makers typically also pursue non-economic goals with trade policies, these estimates may help them gauge the macroeconomic costs of protectionism.

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Online Appendix to ‘The macroeconomic consequences of import tariffs and trade policy uncertainty’

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A Robust sign restrictions from DSGE model

We build a canonical two-country DSGE model to derive sign restrictions for the identification of structural shocks in the empirical Bayesian SVAR that are consistent with theoretical general equilibrium responses. The DSGE model features monopolistic competition, nominal frictions, nontradable and tradable goods, home bias, two nominal noncontingent bonds, and dominant currency pricing. Nevertheless, we aim at keeping it tractable so that we can solve for the steady state analytically and for the policy functions with third-order perturbation methods many times to derive a range of impulse responses to trade policy level and uncertainty shocks for alternative parameter values.

The model consists of two countries with a constant number of households and firms. The countries are symmetric in their structure but may differ in size. We think of country 1 as the US and of country 2 as the rest of the world.

A.1 Households

Households are indexed by $z \in [0,1]$. We assume that househols $z \in [0,n]$ live in country 1 and households $z \in (n,1]$ in country 2 so that n measures the size of country 1 and the population in both countries is normalized to 1. A representative household z in country 1 maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{d_t^1 \left(C_t^1\left(z\right)\right)^{1-\sigma}}{1-\sigma} + \frac{\chi}{1-\epsilon} \left(\frac{M_t^1\left(z\right)}{P_t^1} \right)^{1-\epsilon} - \frac{\kappa}{1+\eta} \left(L_t^{1,S}\left(z\right) \right)^{1+\eta} \right). \tag{A.1}$$

$\beta \in (0,1)$ is the discount factor, d_t^1 a demand shock, M_t^1 nominal money, P_t^1 the final consumption price index, $L_t^{1,S}(z)$ labor supply in the tradable sector, and the superscript denotes country 1. $C_t^1(z)$ is a consumption bundle consisting of a nontradable good $C_{N,t}^1(z)$ and homogeneous tradable goods $C_{T,t}^{1}(z)$ that are combined according to the CES function

$$C_t^1(z) = \left[s^{\frac{1}{\gamma}} \left(C_{N,t}^1(z) \right)^{\frac{\gamma-1}{\gamma}} + (1-s)^{\frac{1}{\gamma}} \left(C_{T,t}^1(z) \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{1-\gamma}},$$

where s is the share of nontradables in the aggregation and γ is the elasticity of substitution between the two types of goods. Taking the level of final consumption $C_t^1(z)$ and the prices of nontradables $P_{N,t}^1$ and tradables $P_{T,t}^1$ as given, the household determines the optimal demand for nontradables and tradables by minimizing input costs. This yields the following demand functions for the two types of goods:

$$C_{N,t}^1(z) = s \left(\frac{P_{N,t}^1}{P_t^1} \right)^{-\gamma} C_t^1(z) \quad \text{and} \quad C_{T,t}^1(z) = (1-s) \left(\frac{P_{T,t}^1}{P_t^1} \right)^{-\gamma} C_t^1(z).$$

Substituting these into the CES function gives the final consumption good price index

$$P_t^1 = \left[s \left(P_{N,t}^1 \right)^{1-\gamma} + (1-s) \left(P_{T,t}^1 \right)^{1-\gamma} \right]^{\frac{1}{1-\gamma}}.$$

The budget contraint of the household is

$$\begin{aligned} & P_t^1 C_t^1(z) + M_t^1(z) - M_{t-1}^1(z) + T_t^1 + B_t^{1,1}(z) + S_t^{1,2} B_t^{2,1}(z) \\ = \;& R_{t-1}^1 B_{t-1}^{1,1}(z) + S_t^{1,2} R_{t-1}^2 B_{t-1}^{2,1}(z) \left(1 - \frac{\psi}{2} B_{t-1}^{2,1} \right) + W_t^1 L_t^{1,S}(z) + \Omega_t^1 + P_{N,t}^1 Y_N^1, \end{aligned} \quad \text{(A.2)}$$

where T_t^1 are nominal tax obligations and $B_t^{1,1}(z)$ a nominal risk-free bond in country 1 currency held by the domestic household and paying gross interest R_{t-1}^1. $S_t^{1,2}$ is the nominal exchange rate defined as the price of country 2 currency in terms of country 1 currency, such that an increase implies a decpreciation of the currency of country 1. $B_t^{2,1}(z)$ is a risk-free bond denominated in country 2 currency paying the risk-free gross rate R_{t-1}^2. Adjusting foreign bond holdings implies a cost goverened by the parameter $\psi > 0$ that induces stationarity of the model. W_t^1 is the nominal wage and Ω_t^1 are per capita profits of the firms owed by the housheolds in country 1. Y_N^1 is the endowment of country 1 with nontradables, like housing or infrastructure. We assume that it is constant in the short run.

The household maximizes (A.1) s.t. (A.2) and we rule out Ponzi schemes. As all households face the same problem, the equilibrium will be symmetric. Thus, we drop the index z to ease the notaion. The first order conditions are

$$\begin{aligned}
\lambda_t^1 &= d_t^1 \left(C_t^1\right)^{-\sigma} \\
\kappa \left(L_t^{1,S}\right)^{\eta} &= \lambda_t^1 \frac{W_t^1}{P_t^1} \\
\lambda_t^1 &= \chi \left(\frac{M_t^1}{P_t^1}\right)^{-\epsilon} + \beta E\left[\frac{\lambda_{t+1}^1}{\Pi_{t+1}^1}\right] \\
\lambda_t^1 &= \beta E\left[\frac{R_t^1 \lambda_{t+1}^1}{\Pi_{t+1}^1}\right] \\
\lambda_t^1 &= \beta E\left[\frac{R_t^2 \lambda_{t+1}^1 S_{t+1}^{1,2}\left(1-\psi B_t^{2,1}\right)}{\Pi_{t+1}^1 S_t^{1,2}}\right],
\end{aligned}$$

where λ_t^1 is the Lagrange multiplier on (A.2) and Π_t^1 is consumer price inflation in country 1. The problem of household z in country 2 is isomorphic in structure.

A.2 Firms in the tradable sector

Each country produces composite tradable goods in two stages. At the upstream, firms are imperfectly competitive. They produce a variety of differentiated intermediate goods. These are used at the downstream domestically and abroad by perfectly competitive firms that produce composite tradable goods. Since upstream firms have monopoly power, tradable output is demand determined in the short-run when prices adjust sluggishly. We assume a constant number of upstream firms, each producing exactly one intermediate tradable good. The number of firms corresponds to the number of households in each country and firms are indexed by z. Firm $z \in [0, n]$ is located in country 1 and firm $z \in (n, 1]$ in country 2.

A.2.1 Final tradable good producers

Intermediate tradable goods are combined to produce the domestic composite tradable good $Y_{T,t}^1$ with the CES production function

$$Y_{T,t}^1 = \left[\left(\frac{1-(1-n)h}{n}\right)^{\frac{1}{\theta}} \int_0^n y_t^{1,1}(z)^{\frac{\theta-1}{\theta}} dz + h^{\frac{1}{\theta}} \int_n^1 y_t^{2,1}(z)^{\frac{\theta-1}{\theta}} dz\right]^{\frac{\theta}{\theta-1}}, \qquad \text{(A.3)}$$

with $\theta > 1$ the elasticity of substitution and $h \in [0, 1]$ the degree of home bias. $y_t^{1,1}(z)$ are intermediate tradable goods produced and used in country 1, $y_t^{2,1}(z)$ are intermediate tradable goods produced in country 2 and imported by country 1. If $h = 1$ there is no home bias, if $h = 0$ there is no international trade. The production weights $\left(\frac{1-(1-n)h}{n}\right)^{\frac{1}{\theta}}$ and $h^{\frac{1}{\theta}}$ are adjusted for country size. For country 2, the weights are $h^{\frac{1}{\theta}}$ and $\left(\frac{1-nh}{1-n}\right)^{\frac{1}{\theta}}$ for $y_t^{1,2}(z)$ and $y_t^{2,2}(z)$, respectively.

The representative composite tradable good producer in country 1 solves the profit maximization problem

$$\max_{y_t^{1,1}(z), y_t^{2,1}(z)} P_{T,t}^1 Y_{T,t}^1 - \int_0^n p_t^1(z) y_t^{1,1}(z) dz - \int_n^1 \left(1+\tau_t^1\right) q_t^1(z) y_t^{2,1}(z) dz$$

subject to the production function (A.3), where $p_t^1(z)$ and $q_t^1(z)$ are the prices of the intermediate tradable goods in country 1 currency, which we assume is the dominant currency. Country 1 producers set prices for both domestic and foreign absorption in country 1 currency. Country 2 producers set prices for domestic absorption in country 2 currency and prices for exports to country 1 in country 1 currency. τ_t^1 is an import tariff of country 1 at the border, implying that the law of one price does not hold in general. The first order conditions to the maximization problem yield the demand for home and foreign intermediate tradable good z:

$$y_t^{1,1}(z) = \frac{1-(1-n)h}{n}\left(\frac{p_t^1(z)}{P_{T,t}^1}\right)^{-\theta} Y_{T,t}^1 \text{ and } y_t^{2,1}(z) = h\left(\frac{\left(1+\tau_t^1\right) q_t^1(z)}{P_{T,t}^1}\right)^{-\theta} Y_{T,t}^1,$$

which depend, other things equal, negatively on the relative price of the tradable good and positively on aggregate tradable production, and imports depend negatively on τ_t^1. The zero profit condition implies that the price (index) of one unit of the composite tradable good equals its minimal cost of production

$$P_{T,t}^1 = \left[\frac{1-(1-n)h}{n}\int_0^n p_t^1(z)^{1-\theta} dz + h\int_n^1 \left(\left(1+\tau_t^1\right) q_t^1(z)\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}.$$

The problem of the composite tradable good producer abroad, and the composite tradable good price index, are analogously.

A.2.2 Intermediate tradable goods producers with dominant currency pricing

Intermediate tradable firms in country 1 produce with a linear production function using labor: $y_t^{S,1}(z) = a_t^1 L_t^{D,1}(z)$, where a_t^1 is a technology shock. Aggregate demand for country 1 intermediate tradable good z is a weighted average of domestic and foreign demand for that good: $y_t^{D,1}(z) = n y_t^{1,1}(z) + (1-n) y_t^{1,2}(z)$. Taking demand and the production function as given, domestic firm z sets $p_t^1(z)$ in the dominant currency (its own) to maximize profits

$$\Omega_t^1(z) = p_t^1(z) y_t^{D,1}(z) - W_t^1 L_t^{D,1}(z) - AC_t^1(z)$$

and takes into account a quadratic cost of price adjustment $AC_t^1(z) = \frac{\phi}{2}\left(\frac{p_t^1(z)}{p_{t-1}^1(z)} - 1\right)^2 p_t^1 y_t^1$. In the symmetric equilibrium, the nonlinear Phillips curve for country 1 producer price inflation π_t^{p1} is

$$1 = \left(1 - \frac{W_t^1}{p_t^1 a_t^1}\right)\theta + \phi\left(\pi_t^{p1} - 1\right)\pi_t^{p1} - \beta E\left[\frac{\lambda_{t+1}^1}{\lambda_t^1}\phi\left(\pi_{t+1}^{p1} - 1\right)\pi_{t+1}^{p1}\frac{y_t^1}{y_{t+1}^1}\right].$$

Intermediate tradable firms in country 2 also use a linear production function but segment the domestic and foreign market $y_t^{S,2,2}(z) + y_t^{S,2,1}(z) = a_t^2 L_t^{D,2}(z)$. Producer z sets the price $p_t^2(z)$ for goods for the domestic market in country 2 currency and the price q_t^1 for exports in the dominant country 1 currency. Its profits are

$$\Omega_t^2(z) = p_t^2(z)\, y_t^{D,2,2}(z) + S_t^{2,1} q_t^1 y_t^{D,2,1}(z) - W_t^2 L_t^{D,2}(z) - AC_t^{2,p}(z) - AC_t^{2,q}(z)$$

with $AC_t^{2,p}(z) = \frac{\phi}{2}\left(\frac{p_t^2(z)}{p_{t-1}^2(z)} - 1\right)^2 p_t^2 y_t^{2,2}$ and $AC_t^{2,q}(z) = \frac{\phi}{2}\left(\frac{q_t^1(z)}{q_{t-1}^1(z)} - 1\right)^2 S_t^{2,1} q_t^1 y_t^{2,1}$. The Phillips curves for domestic and export prices, respectively, are

$$\begin{aligned} 1 &= \left(1 - \frac{W_t^2}{p_t^2 a_t^2}\right)\theta + \phi\left(\pi_t^{p2} - 1\right)\pi_t^{p2} - \beta E\left[\frac{\lambda_{t+1}^2}{\lambda_t^2}\phi\left(\pi_{t+1}^{p2} - 1\right)\pi_{t+1}^{p2}\frac{y_t^{22}}{y_{t+1}^{22}}\right] \\ 1 &= \left(1 - \frac{W_t^2}{S_t^{2,1} q_t^1 a_t^2}\right)\theta + \phi\left(\pi_t^{q1} - 1\right)\pi_t^{q1} - \beta E\left[\frac{\lambda_{t+1}^2}{\lambda_t^2}\phi\left(\pi_{t+1}^{q1} - 1\right)\pi_{t+1}^{q1}\frac{y_t^{21}}{y_{t+1}^{21}}\right]. \end{aligned}$$

A.3 Policy, shocks, and equilibrium

We assume that monetary authorities in both countries implement a money growth rule.[18] Tariff proceeds are redistributed to domestic households lump-sum. The consolidated government budget constraint of country 1 is

$$0 = T_t^1 + M_t^1 - M_{t-1}^1 + (1-n)\,\tau_t^1 q_t^1 y_t^{21}.$$

. We assume that trade policy is exogenous in both countries. The domestic tariff rate follows an AR(1) process with stochastic volatility:

$$\begin{aligned} \tau_t^1 &= (1-\rho)\,\tau^1 + \rho\tau_{t-1}^1 + \omega_{t-1}\varepsilon_t \\ \omega_t &= (1-\rho)\,\omega + \rho\omega_{t-1} + \mu\nu_t, \end{aligned}$$

where ε_t and ν_t are *iid* standard normal innovations to the level and variance of tariffs, respectively, and variables without time-subscript denote their steady state. We refer to τ_t^1 as tariff shocks and to ω_t as trade policy uncertainty shocks. We allow for retaliation of the foreign country in an ad-hoc form:

$$\tau_t^2 = (1-\rho)\,\tau^2 + \rho\tau_{t-1}^2 + \zeta\omega_{t-1}\varepsilon_t,$$

with $\zeta \in [0,1]$. $\zeta = 0$ is no retaliation and $\zeta = 1$ is full retaliation. The demand shock d_t^1 and the technology shock a_t^1 also follow AR(1) processes. Central banks in both countries keep the nominal money supply constant. The equilibirum is symmetric as households and firms each face the same problem. Goods, labor, and money markets clear, and both bonds are in zero net supply. The equilibrium definition is standard. The net foreign asset position of country 1 evolves according to

$$\begin{aligned} & P_t^1 C_t^1 + B_t^{1,1} + S_t^{1,2} B_t^{2,1} + AC_t^1 \\ = \; & R_{t-1}^1 B_{t-1}^{1,1} + S_t^{1,2} R_{t-1}^2 B_{t-1}^{2,1}\left(1 - \frac{\psi}{2} B_{t-1}^{2,1}\right) + p_t^1 y_t^1 + (1-n)\,\tau_t^1 q_t^1 y_t^{21} + P_{N,t}^1 Y_N^1 \end{aligned}$$

[18]Assuming a Taylor rule in both countries yields qualitatively the same results but complicates the simulation of the model for alternative parameter values as more parameter combinations yield indeterminacy/instability.

Parameter	Symbol	Value/Distribution	Mean	S.d.
Calibrated				
Discount factor	β	1/1.01		
Disutility hours	κ	0.8333		
Utility money	χ	0.0099		
Tariff rate	τ	0.036		
S.d. technology level shocks	ω	0.01		
S.d. technology volatility shocks	μ	0.01		
Distributions				
Risk aversion	σ	Inverse gamma	1	0.25
Inverse Frisch Elasticity	η	Inverse gamma	1	0.25
Elasticity money demand	ϵ	Inverse gamma	3	0.5
Transaction costs bonds	ψ	Inverse gamma	0.0025	10
Country size	n	Beta	0.5	0.25
Retaliation	ζ	Beta	0.5	0.25
Share nontradables	s	Beta	0.2	0.05
Home bias	h	Beta	0.9	0.025
Persistence shocks	ρ	Beta	0.9	0.025
Elasiticity non-/tradables	γ	Normal	6	2
Elasiticity intermediate tradables	θ	Normal	6	2
Price adjustment cost	ϕ	Normal	60	15

Table A.1: Parameter values and distributions for simulation analysis.

A.4 Calibration and prior distributions

We calibrate some parameters and specify distributions for others to solve the model and obtain impulse responses to level and uncertainty shocks. Table A.1 summarizes the choices. We set $\beta = 1/1.01, W^j = \frac{\theta-1}{\theta}, \kappa = \frac{W^j}{(1-s)^\eta}, \chi = (1-\beta), \tau^j = 0.036$ for $j = 1, 2$, and we assume zero inflation in steady state. These are standard values. We calibrate them because they mainly affect the deterministic steady state.

The remaining parameters are more important for the signs of the impact effects and for the dynamics. We specify independent distributions, which are typically used as priors for the estimation of DSGE models.

The preference parameters are relevant for the dynamics as they determine the labor response and the willingness of households to substitute consumption intertemporally. We allow for variation in the (inverse) Frisch labor supply elasticity η, the coefficient of relative risk aversion σ, and the money demand elasticity ϵ. We choose inverse gamma distributions with mean 1, 1, 3 and standard deviation of 0.25, 0.25, and 0.5, respectively. We specifiy the same distribution type for the portfolio adjustment cost parameter ψ but with mean 0.0025 and standard deviation 10.

For the country size n, the share of nontradables s, and the degree of retaliation ζ, we use beta distributions with mean of 0.5, 0.2, and 0.5 and standard deviations of 0.25, 0.05, and 0.25, respectively. Another important parameter is the persistence of the shocks ρ, which is central to wealth effects. We specify a fairly high autocorrelation as a baseline but allow for lower values as well, by using a beta distribution with mean 0.9 and standard deviation 0.025. We use the same distribution for the home bias h.

For the elasticity of substitution between nontradables and tradables γ and the elasticity of substitution between tradable intermediates θ, we use normal distributions with mean 6 and standard deviation 2. The price adjustment cost parameter ϕ determines how much output is demand determined. We use a normal prior distribution with mean 60 and standard deviation 15. We truncate all distributions at the 1% and 99% level to remove extreme values and ensure stability and determinacy of the model.

The calibrated and mean values yield a per-period interest rate of 1% in steady state, an interest rate elasticity of money demand of −0.33, a consumption elasticity of 0.33, and a markup over marginal cost of 20%.

We draw 5,000 parameter combinations from the distributions. For each combination, we compute the impulse responses to the four shocks. For the uncertainty shock, we compute a third-order approximation with pruning and simulate the model for 1000 periods without shocks to obtain the stochastic steady state, that is, the ergodic mean in the absence of shocks. We discard the first 1000 periods as burn-in and feed in an uncertainty shock that doubles the standard deviation of the tariff level shocks.

The impulse responses to the tariff level and uncertainty shock are in the main text. Here, we show the responses to the demand shock d_t^1 and the technology shock a_t^1 to derive further sign restrictions for the Bayesian SVAR. Figure A.1 shows the responses to a positive demand shock. The impact effects are in line with standard theory. Consumer prices, producer prices, imports, and output all increase. The nominal exchange rate depreciates. The trade balance declines. The credible sets of the real exchange rate and the export response cover zero. Figure A.2 shows the responses to a positive supply shock. Again, the impact effects are standard. Prices fall and output increases. The nominal and the real exchange rate appreciate. Exports rise while imports decline such that the trade balance rises. All impact effects are distinguishable from zero.

Figure A.1: Distributions of impact responses of country 1 to a demand shock in country 1. *Notes:* The figure shows the frequency distributions of the responses to a shock of 1% to the demand shifter d_t^1 in country 1.

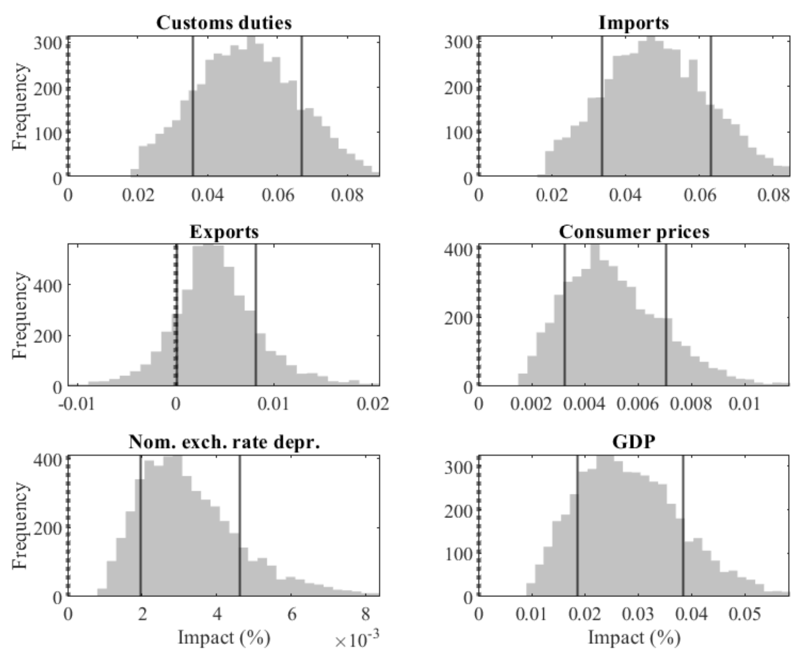
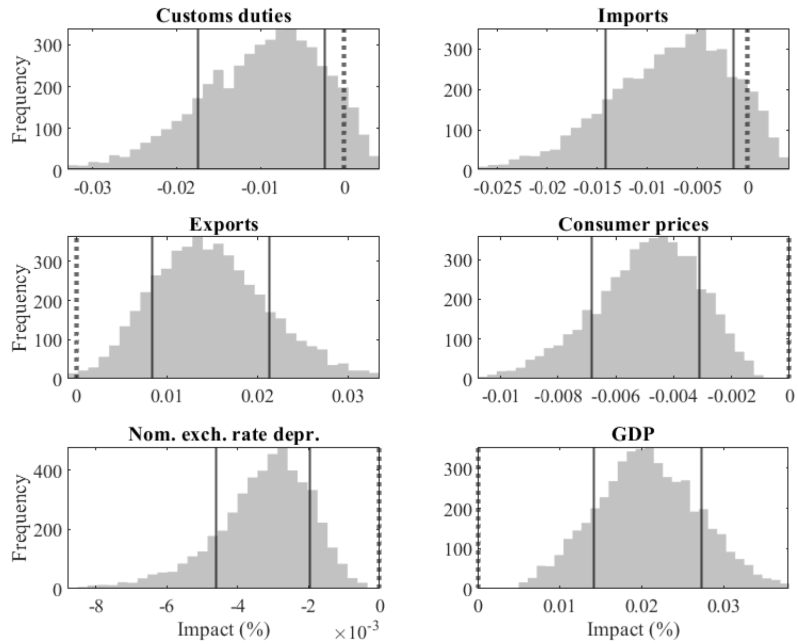


Figure A.2: Distributions of impact responses of country 1 to a supply shock in country 1. *Notes:* The figure shows the frequency distributions of the responses to a shock of 1% to the technology shock a_t^1 in country 1.



A.5 Producer currency pricing and local currency pricing

We consider two modifications of the model to assess the robustness of the sign restrictions for tariff level and uncertainty shocks. In the main text, we assume dominant currency pricing. Now, we assume either producer currency pricing or local currency pricing. The alternative pricing assumptions mainly affect the optimization problem of the intermediate tradable goods firms, which we sketch in the following.

Under producer currency pricing, the problem of the intermediate tradable goods firms in country 1, the dominant currency country, does not change relative to the main text. These firms continue to set prices in domestic currency only. For country 2, the demand for intermediate tradable goods firm z is $y_t^{D,2}(z) = ny_t^{2,1}(z) + (1-n)\, y_t^{2,2}(z)$. The production function is $y_t^{S,2}(z) = a_t^2 L_t^{D,2}(z)$. Taking demand and the production function as given, firm z sets the price in domestic currency $p_t^2(z)$ to maximize profits

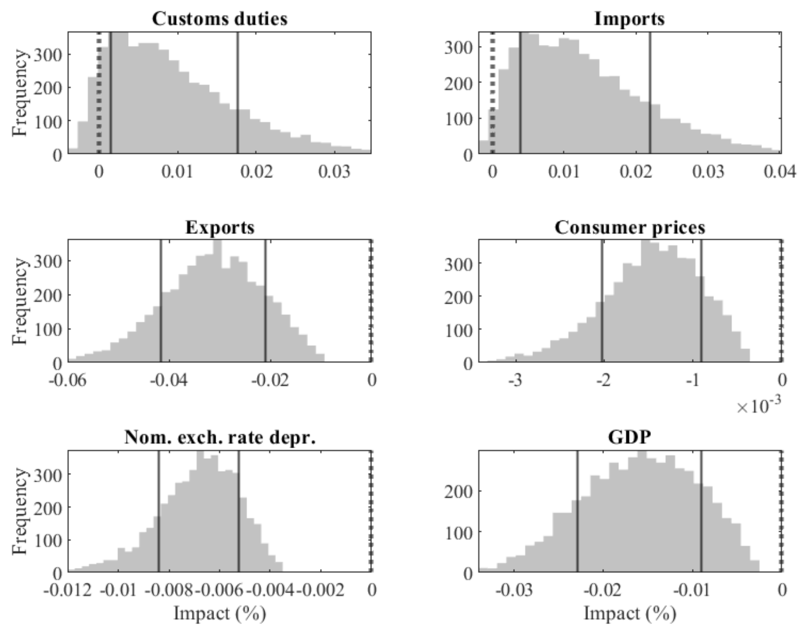
$$\Omega_t^2(z) = p_t^2(z)\, y_t^{D,2}(z) - W_t^2 L_t^{D,2}(z) - AC_t^2(z)$$

and takes into account a quadratic cost of price adjustment $AC_t^2(z) = \frac{\phi}{2}\left(\frac{p_t^2(z)}{p_{t-1}^2(z)} - 1\right)^2 p_t^2 y_t^2$. In the symmetric equilibrium, the nonlinear Phillips curve for country 2 producer price inflation π_t^{p2} is

$$1 = \left(1 - \frac{W_t^2}{p_t^2 a_t^2}\right)\theta + \phi\left(\pi_t^{p2} - 1\right)\pi_t^{p2} - \beta E\left[\frac{\lambda_{t+1}^2}{\lambda_t^2}\phi\left(\pi_{t+1}^{p2} - 1\right)\pi_{t+1}^{p2}\frac{y_t^2}{y_{t+1}^2}\right],$$

where λ_t^2 is the shadow value of wealth.

Figure A.3: Distributions of impact responses of country 1 to a tariff news shock in country 1. *Notes:* The figure shows the frequency distributions of the impact responses to an one-quarter anticipated shock of 1% point to the tariff rate τ_t^1 in country 1.



Under local currency pricing, the problem of the intermediate tradable goods firms in country 2, the non-dominant currency country, does not change relative to the main text. These firms continue to set prices in domestic currency for the domestic market and in foreign currency for the export market. But intermediate tradable firms in country 1 now also segmet markets: $y_t^{S,1,1}(z) + y_t^{S,1,2}(z) = a_t^1 L_t^{D,1}(z)$. Producer z sets the price $p_t^1(z)$ for goods for the domestic market in country 1 currency and the price q_t^2 for exports in country 2 currency. Its profits are

$$\Omega_t^1(z) = p_t^1(z)\, y_t^{D,1,1}(z) + S_t^{1,2} q_t^2 y_t^{D,1,2}(z) - W_t^1 L_t^{D,1}(z) - AC_t^{1,p}(z) - AC_t^{1,q}(z)$$

with $AC_t^{1,p}(z) = \frac{\phi}{2}\left(\frac{p_t^1(z)}{p_{t-1}^1(z)} - 1\right)^2 p_t^1 y_t^{1,1}$ and $AC_t^{1,q}(z) = \frac{\phi}{2}\left(\frac{q_t^2(z)}{q_{t-1}^2(z)} - 1\right)^2 S_t^{1,2} q_t^2 y_t^{1,2}$. The Phillips curves for domestic and export prices, respectively, are

$$\begin{aligned} 1 &= \left(1 - \frac{W_t^1}{p_t^1 a_t^1}\right)\theta + \phi\left(\pi_t^{p1} - 1\right)\pi_t^{p1} - \beta E\left[\frac{\lambda_{t+1}^1}{\lambda_t^1}\phi\left(\pi_{t+1}^{p1} - 1\right)\pi_{t+1}^{p2}\frac{y_t^{11}}{y_{t+1}^{22}}\right] \\ 1 &= \left(1 - \frac{W_t^1}{S_t^{1,2} q_t^2 a_t^1}\right)\theta + \phi\left(\pi_t^{q2} - 1\right)\pi_t^{q2} - \beta E\left[\frac{\lambda_{t+1}^1}{\lambda_t^1}\phi\left(\pi_{t+1}^{q2} - 1\right)\pi_{t+1}^{q2}\frac{y_t^{12}}{y_{t+1}^{12}}\right]. \end{aligned}$$

Figure A.4 shows the distributions of the impact responses to a tariff level and uncertainty shock under producer currency pricing. Figure A.5 shows the distributions of the impact responses to a tariff level and uncertainty shock under local currency pricing. The signs of the impact effects do not change relative to the baseline model that assumes dominant currency pricing.

Figure A.4: Frequency distributions of impacts under producer currency pricing.

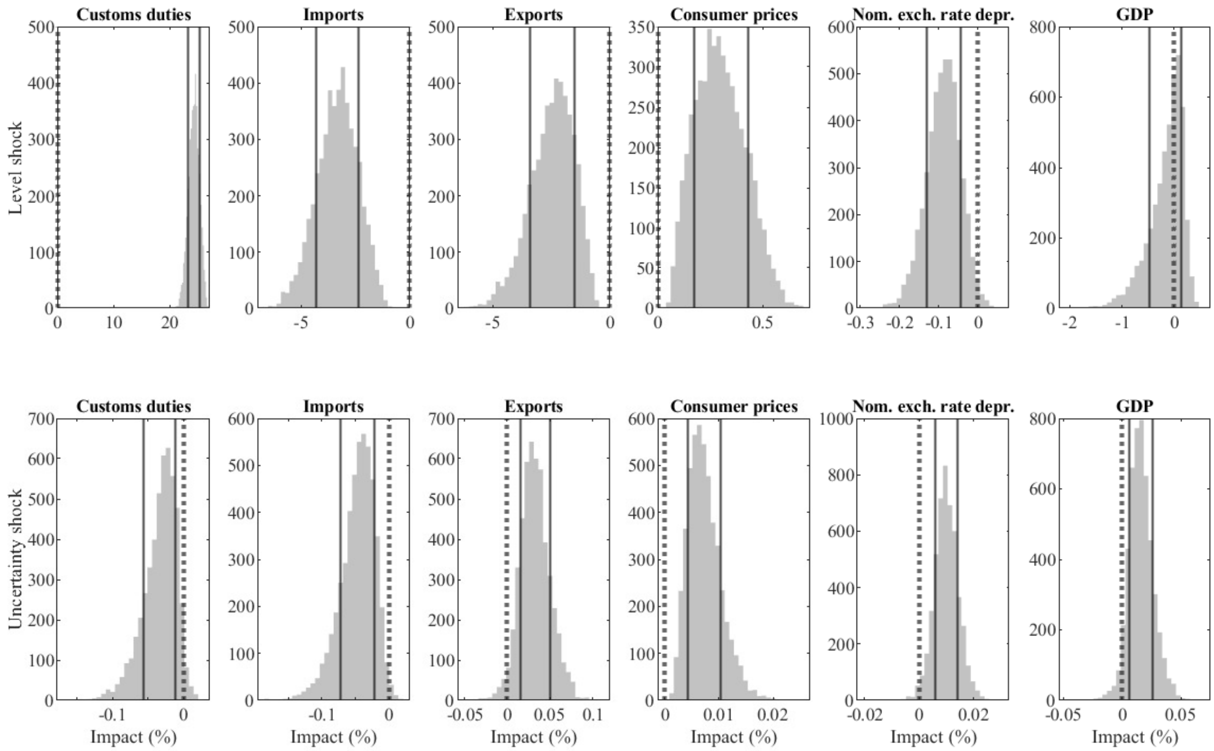
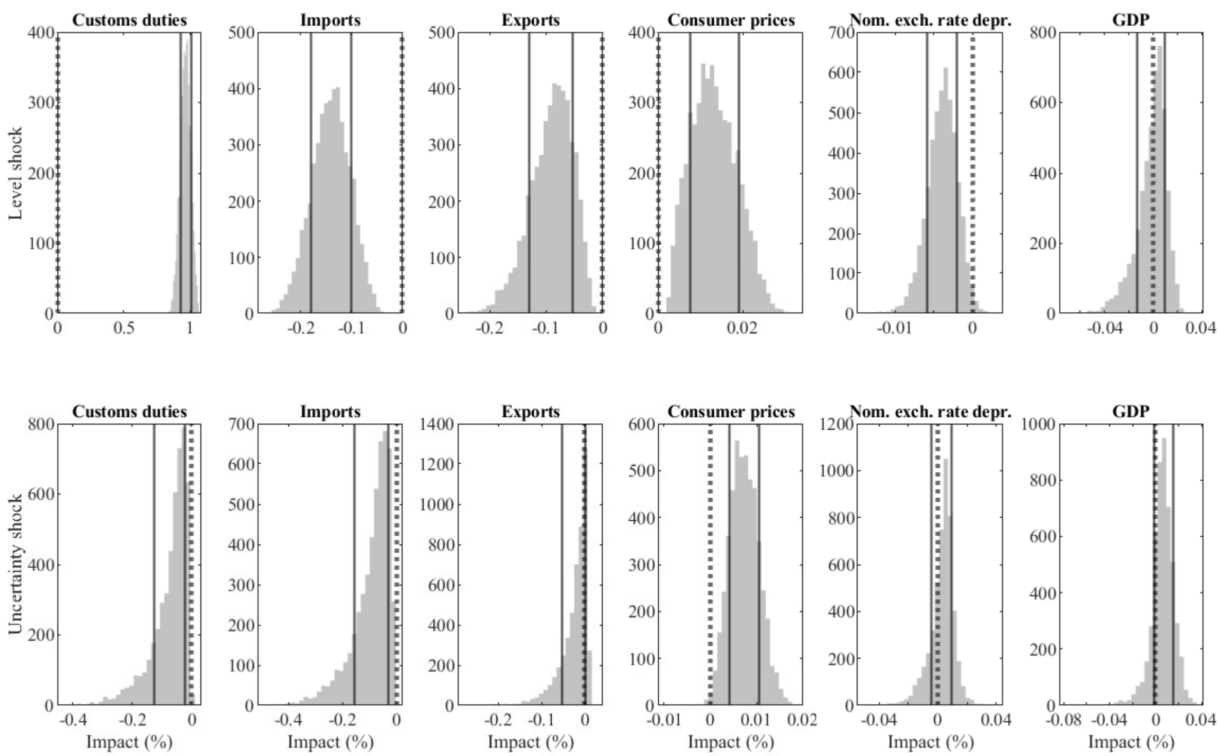


Figure A.5: Frequency distributions of impacts under local currency pricing.



B Data

Gross domestic product and custom duties are downloaded from the US Bureau of Economic Analysis and both series are seasonally adjsuted. Imports and exports of goods are taken from the OECD's main economic indicators database and are seasonally adjusted. The series have been adjusted for inflation with the total consumer price index for all goods that is also downloaded from the OECD database. The real effective exchange rate is taken from Darvas (2021). It is defined as $Q_{US,t} = S_{US,t} \cdot \frac{P_{US,t}}{P_{W,t}}$ The real effective exchange rate $Q_{US,t}$ is based on the OECD's consumer price indices for the US $P_{US,t}$ and for the world $P_{W,t}$, calculated as an average over 51 trading partners' price indices. The nominal exchange rate $S_{US,t}$ is a weighted average over the 51 trading partners' currencies. An increase in the index represents a real appreciation of the US Dollar. Monthly values are averaged to obtain quarterly values. The tariff rate τ is calculated from custom duties CD and imports M as $\tau = \frac{CD}{M}$.

Table A.2: Data Description, Sources and Coverage

Variable	Description	Source	Sample
Baseline Variables			
GDP	Gross Domestic Product (s.a.)	FRED	1960q1 - 2019q4
CPI	Total CPI - all goods	OECD	1960q1 - 2019q4
Goods Imports	Imports in goods (value)	OECD	1960q1 - 2019q4
Goods Exports	Exports in goods (value)	OECD	1960q1 - 2019q4
B235RC1Q027SBEA	Customs Duties (s.a.)	FRED	1960q1 - 2019q4
Nominal Effective Exchange Rate	Zsolt Darvas (2021), against 51 trading partners, quarterly average	Bruegel webpage	1960q1 - 2019q4
Trade Policy Uertainty	Caldara et al. (2020)	Iacoviello's webpage	1960q1 - 2019q4
Additional Variables			
W170RC1Q027SBEA	Gross Domestic Investment (s.a.)	FRED	1960q1 - 2019q4
PAYEMS	All Employees, Total Nonfarm (s.a.)	FRED	1960q1 - 2019q4
PCEC	Personal Consumption Expenditures (s.a.)	FRED	1960q1 - 2019q4
Trade Balance	Net Exports as (Goods Exports - Goods Imports)/GDP		1960q1 - 2019q4
Real Effective Exchange Rate	Zsolt Darvas (2021), against 51 trading partners, quarterly average	Bruegel webpage	1960q1 - 2019q4
BOGZ1FL072052006Q	Effective Federal Funds Rate	FRED	1960q1 - 1989q4
Shadow Federal Funds Rate	Wu and Xia (2016)	Wu's webpage	1990q1 - 2019q4
Utilization-adjusted quarterly-TFP	Fernald (2014)	Fernald's webpage	1960q1 - 2019q4
Tariff Rate	Customs Duties/Goods Imports		1960q1 - 2019q4
IMPGS	Imports of Goods and Services (s.a.)	FRED	1960q1 - 2019q4
EXPGS	Exports of Goods and Services (s.a.)	FRED	1960q1 - 2019q4
PPI	Producer Price Index	OECD	1960q1 - 2019q4
B255RG3Q086SBEA	Goods Import Prices (s.a.) (deflator)	FRED	1960q1 - 2019q4
B253RG3Q086SBEA	Goods Export Prices (s.a.) (deflator)	FRED	1960q1 - 2019q4
Terms of Trade	Goods Export Prices/ Goods Import Prices	FRED	1960q1 - 2019q4
Sectoral Data			
Employment sectoral		Macrobond	1960q1 - 2019q4
Employment by states	51 states	Macrobond	1960q1 - 2019q4
FNSCM, FNSMG, FNSPC, FNSMN, FNSO, FNEN, FNEI, FNET, FNEO, FNPS, FNPR, FNPE, FRSH1, FRSH2, FRSO, FRE, FSS, FSSN, FNQS (all @USNA)	Sectoral Investment	Haver Analytics	1960q1 - 2019q4
TMMEFBAC, TMMEIMAC, TMMECGAC, TMMEAVAC, TMMECNAC, TMMEOMAC (all @USECON)	Imports by End-use	Haver Analytics	1986q1 - 2019q4
TMXEFBA, TMXEIMA, TMXECGA, TMXEAVA, TMXECNA, TMXEOMA (all @USECON)	Exports by End-use	Haver Analytics	1986q1 - 2019q4
MSITC00, MSITC01, ... MSITC09 (all @USECON)	Sectoral Imports by SITC	Haver Analytics	1978q1 - 2019q4
XSITC00, XSITC01, ... XSITC09, XSITCFGN (all @USECON)	Sectoral Exports by SITC	Haver Analytics	1978q1 - 2019q4

C Additional SVAR results

C.1 Additional results for main model

Figure A.6: Impulse responses to tariff level shock and trade policy uncertainty shock for all draws. *Notes:* The figure shows the responses for each of the 1000 draws with point-wise median impulse responses (solid red), 68% highest posterior density credible sets (dotted red), and modal model using an absolute loss function (dashed green).

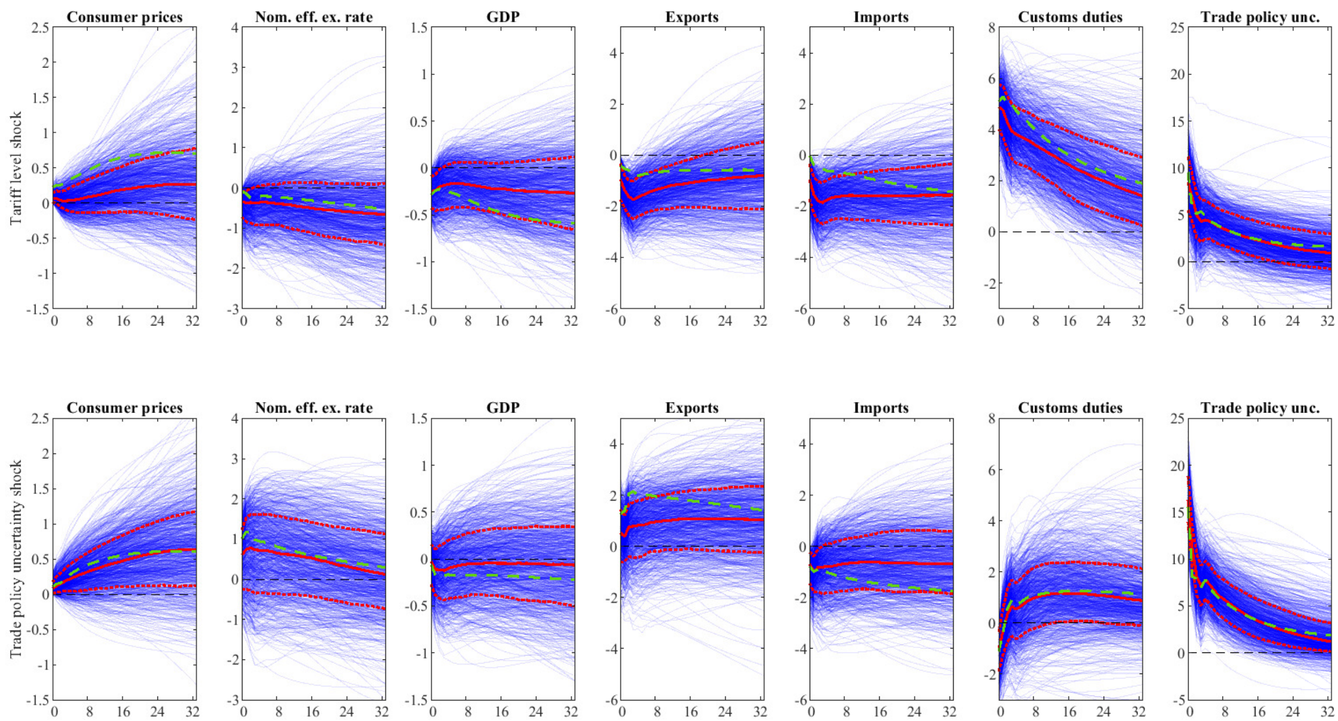


Figure A.7: Impulse responses to all four types of shocks. *Notes:* The figure shows the structural impulse responses to a tariff level shock, a trade policy uncertainty shock, a domestic demand shock, and a domestic supply shock in rows on the endogenous variables in columns. It reports point-wise median impulse responses and 68% highest posterior density credible sets.

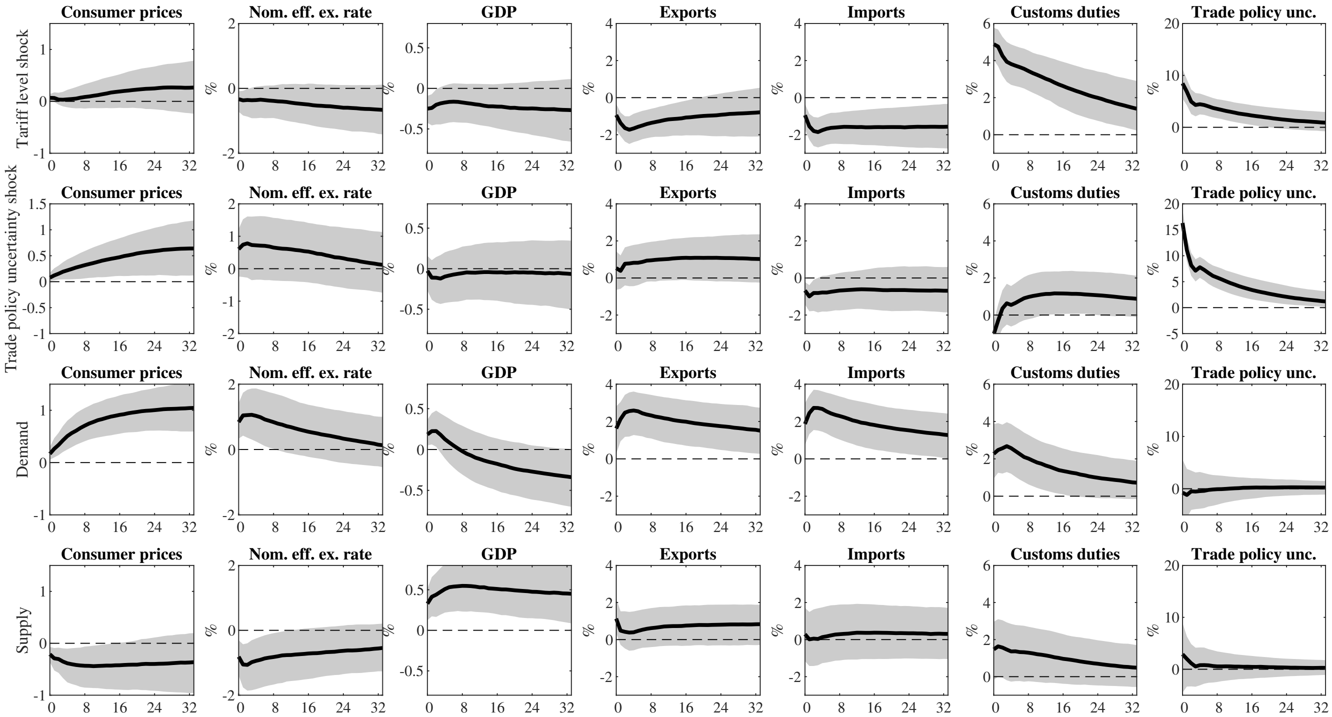


Figure A.8: Historical decomposition of customs duties and trade policy uncertainty. *Notes:* Thick back lines show actual detrended data, thin blue lines show counterfactuals driven by the respective shock only.

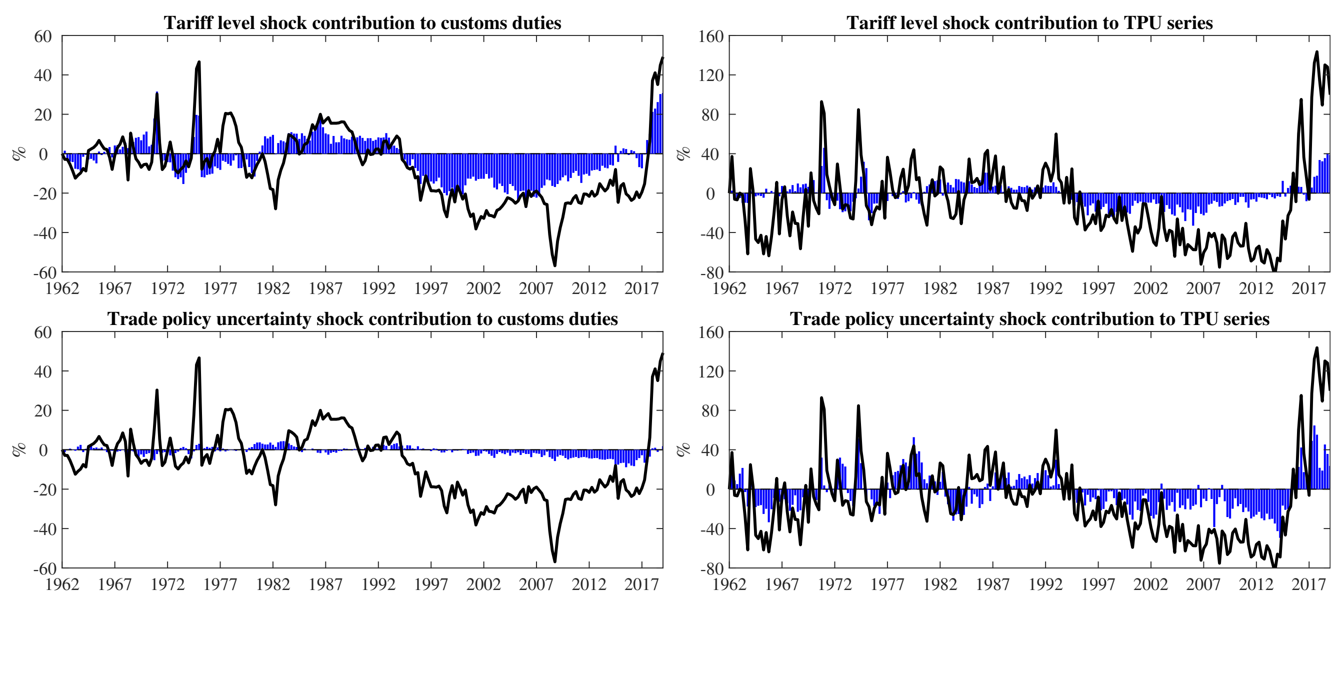


Figure A.9: Historical decomposition of output 2016Q1-2019Q4. *Notes:* Thick back lines show actual detrended data, thin blue lines show counterfactuals driven by the respective shock only.

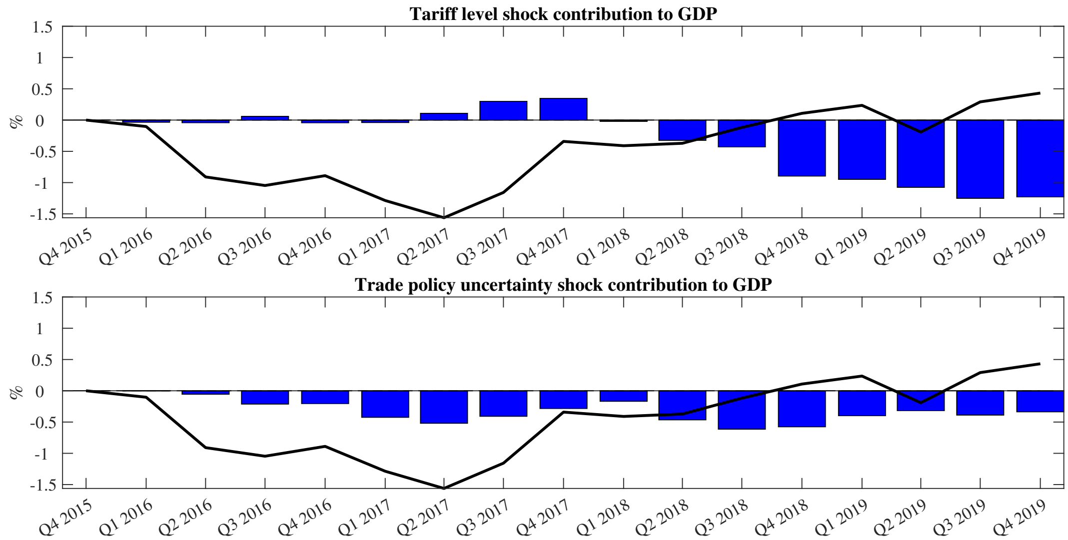
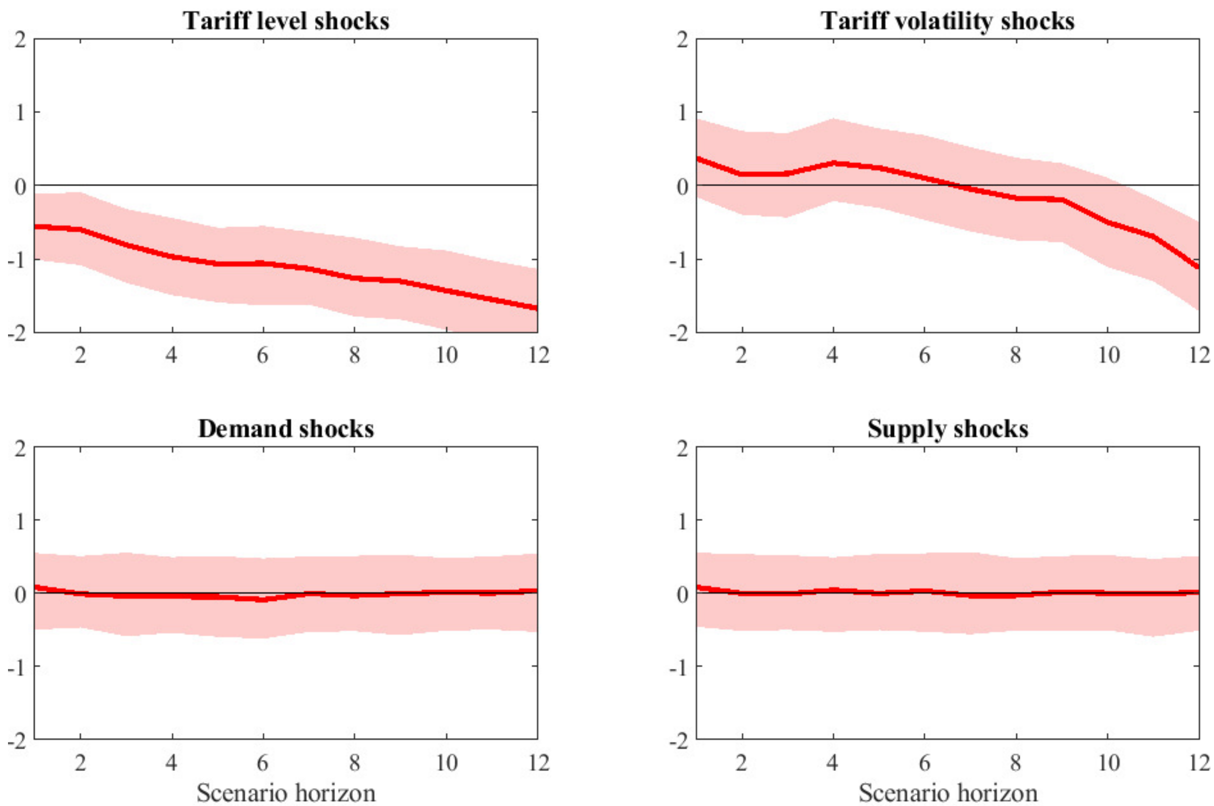


Figure A.10: Shock series in the scenario of a phasing out of tariffs. *Notes:* The red solid lines and shaded regions are the median and 40% point-wise credible sets for the shock series in the scenario 'Tariff phase out'.



C.2 Results of sectoral analysis

Figure A.11: Responses of sectoral imports to a tariff level shock. *Notes:* The figure shows the responses of sectoral imports obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

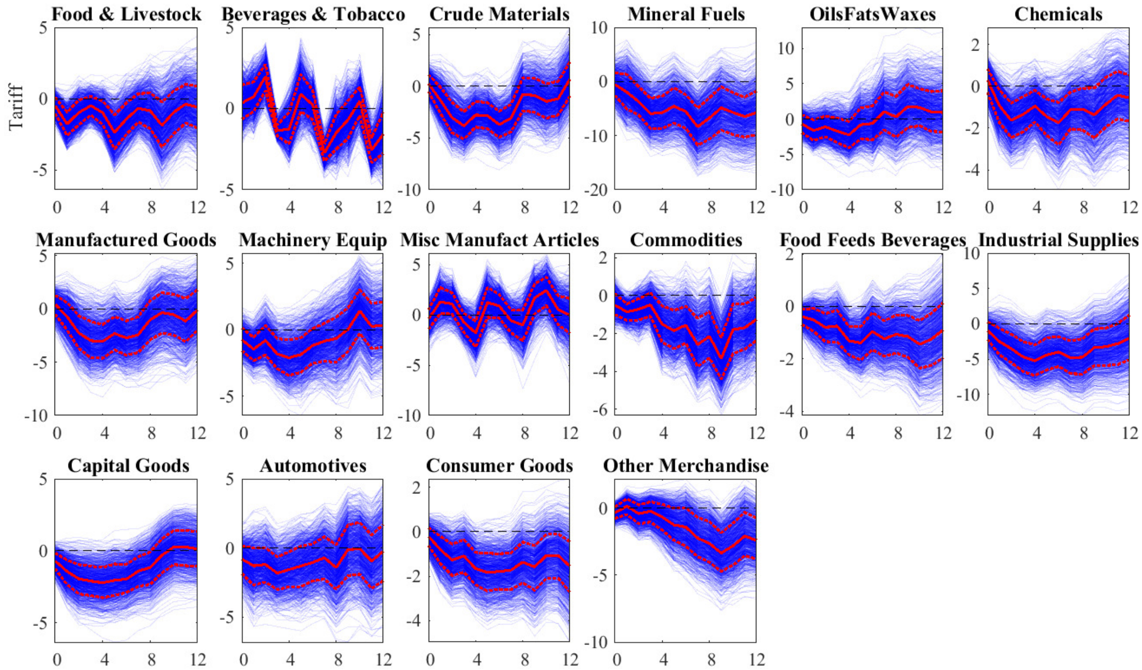


Figure A.12: Responses of sectoral exports to a tariff level shock. *Notes:* The figure shows the responses of sectoral exports obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

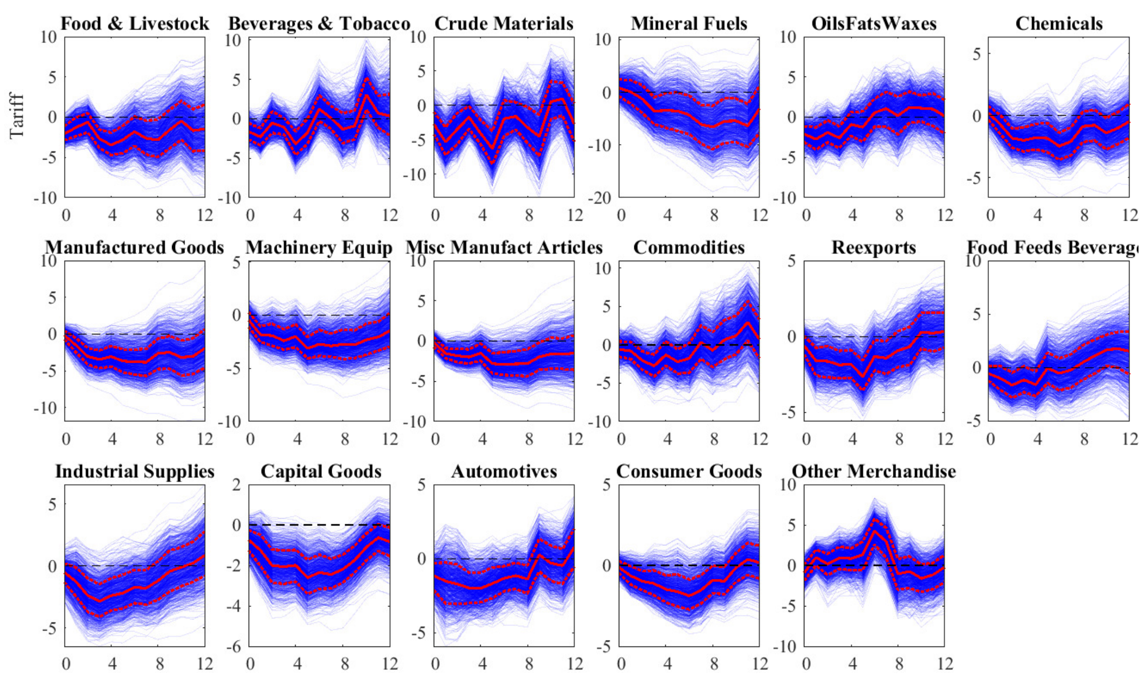


Figure A.13: Responses of sectoral investment to a tariff level shock. *Notes:* The figure shows the responses of sectoral investment obtained from local projections.

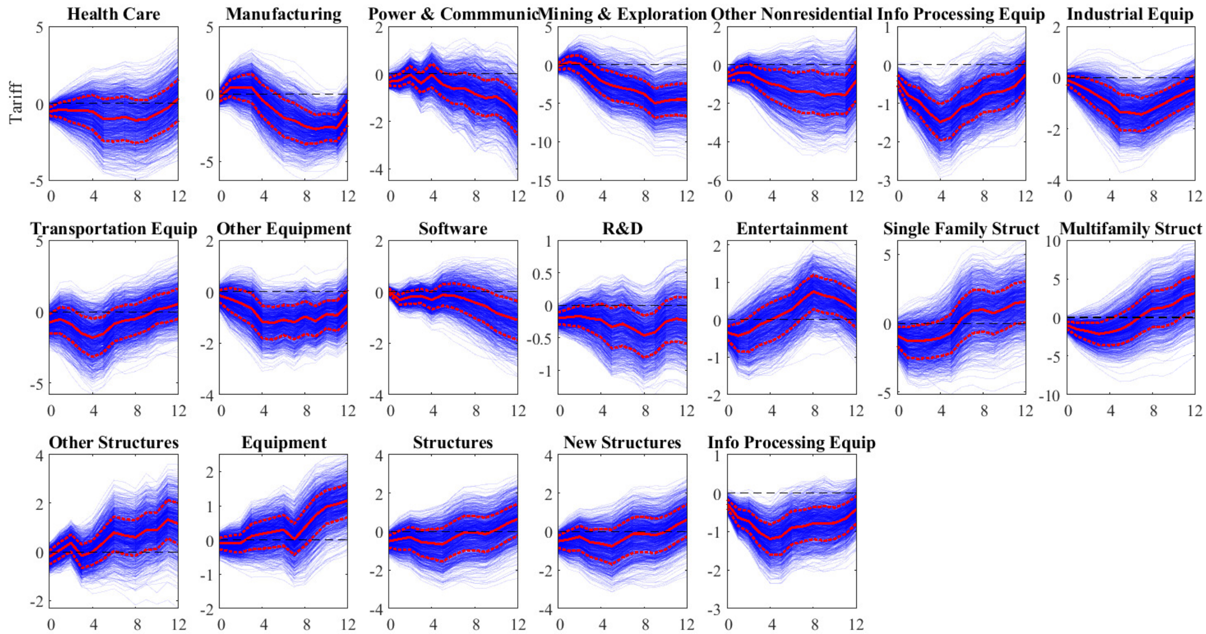


Figure A.14: Responses of sectoral employment to a tariff level shock. *Notes:* The figure shows the responses of sectoral employment obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

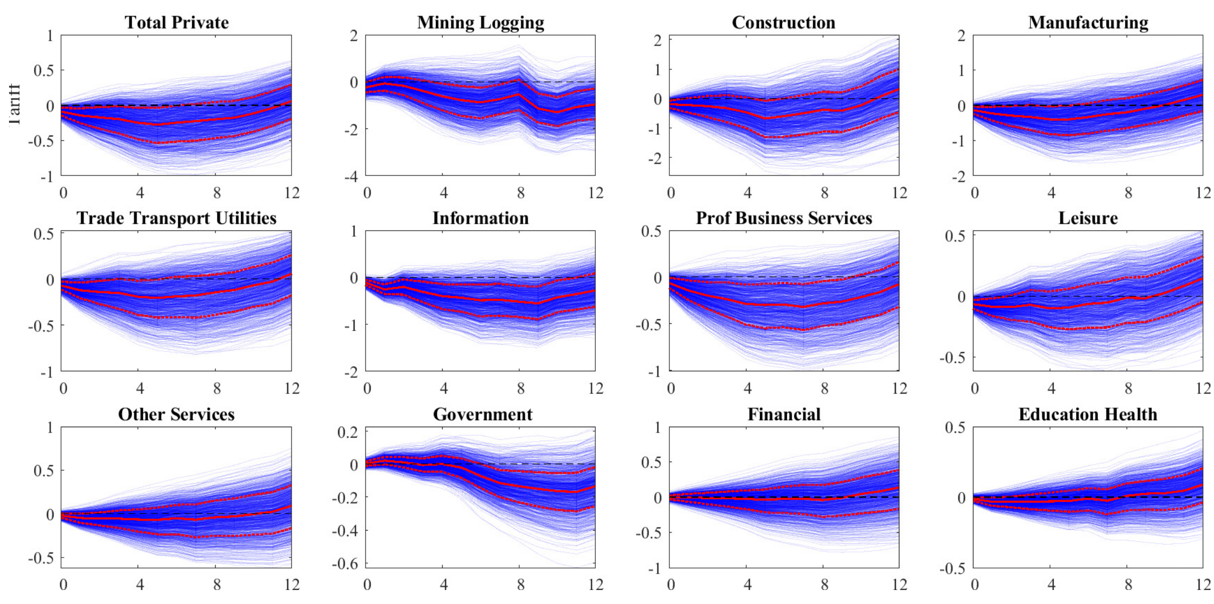


Figure A.15: Responses of sectoral imports to a trade policy uncertainty shock. *Notes:* The figure shows the responses of sectoral imports obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

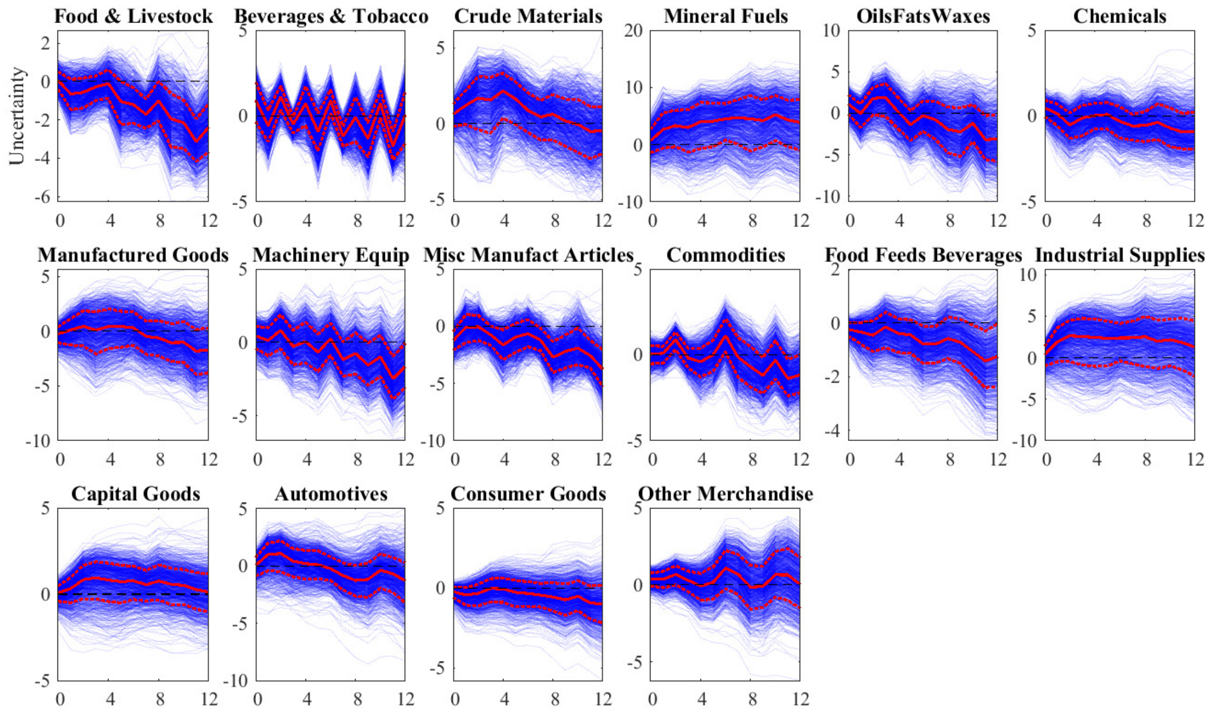


Figure A.16: Responses of sectoral exports to a trade policy uncertainty shock. *Notes:* The figure shows the responses of sectoral exports obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

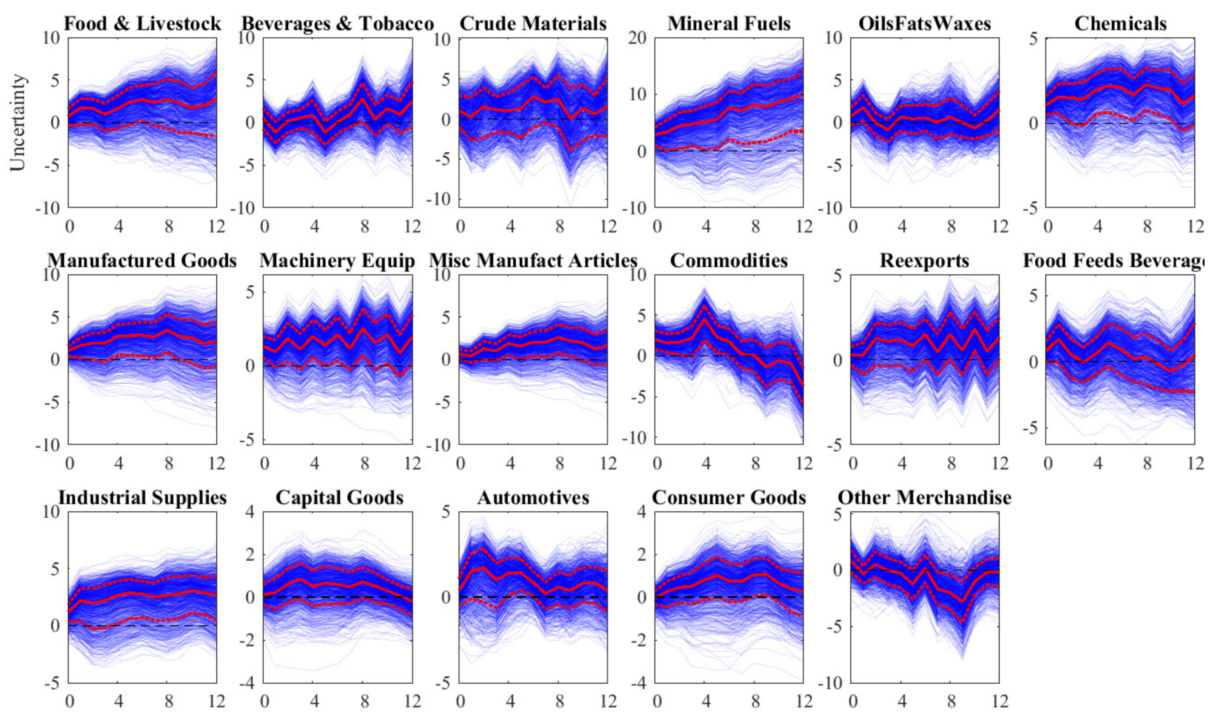


Figure A.17: Responses of sectoral investment to a trade policy uncertainty shock. *Notes:* The figure shows the responses of sectoral investment obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

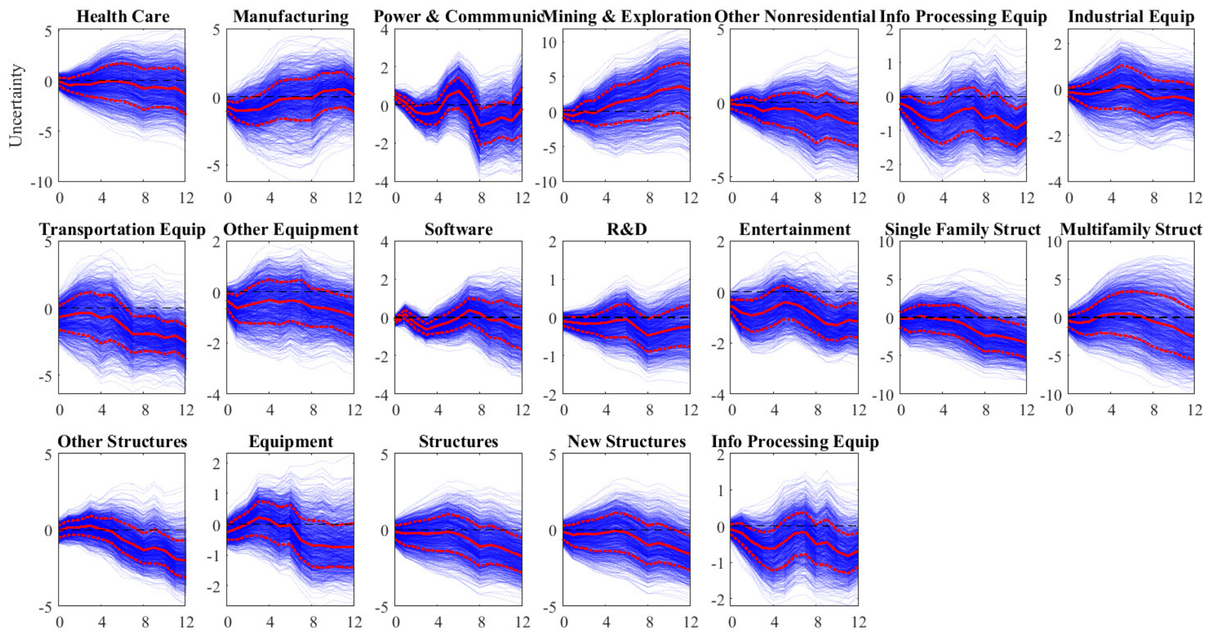


Figure A.18: Responses of sectoral employment to a trade policy uncertainty shock. *Notes:* The figure shows the responses of employment obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

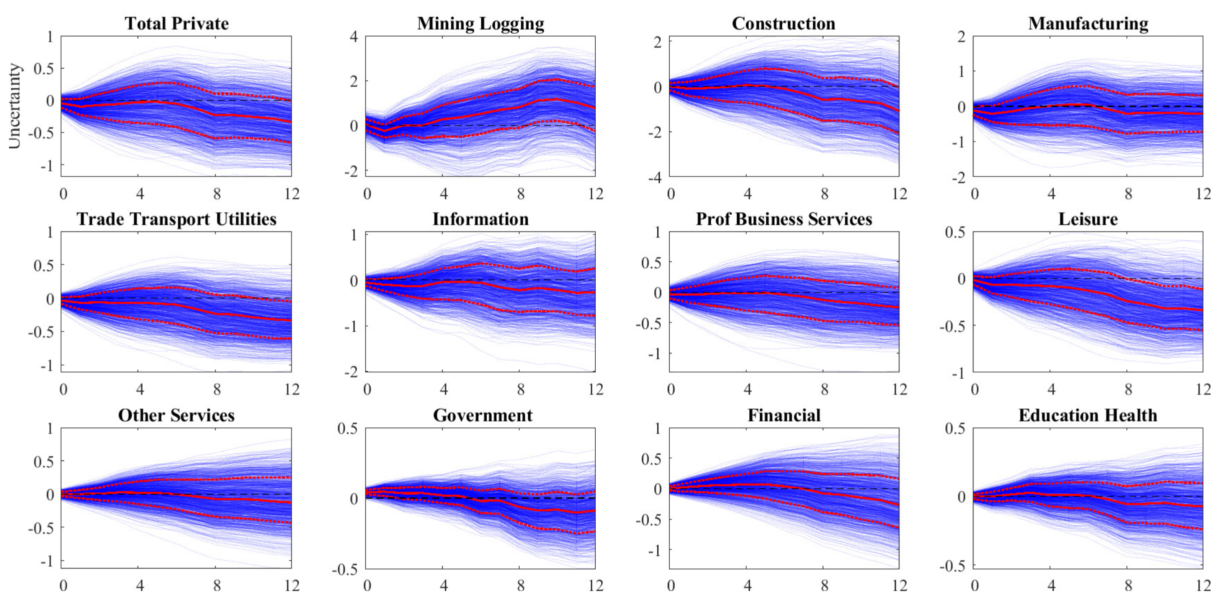


Figure A.19: Responses of state employment to a tariff level shock. *Notes:* The figure shows the responses of state employment obtained from local projections. It shows the responses for each of the 1000 draws and the point-wise median and 68% highest posterior density sets.

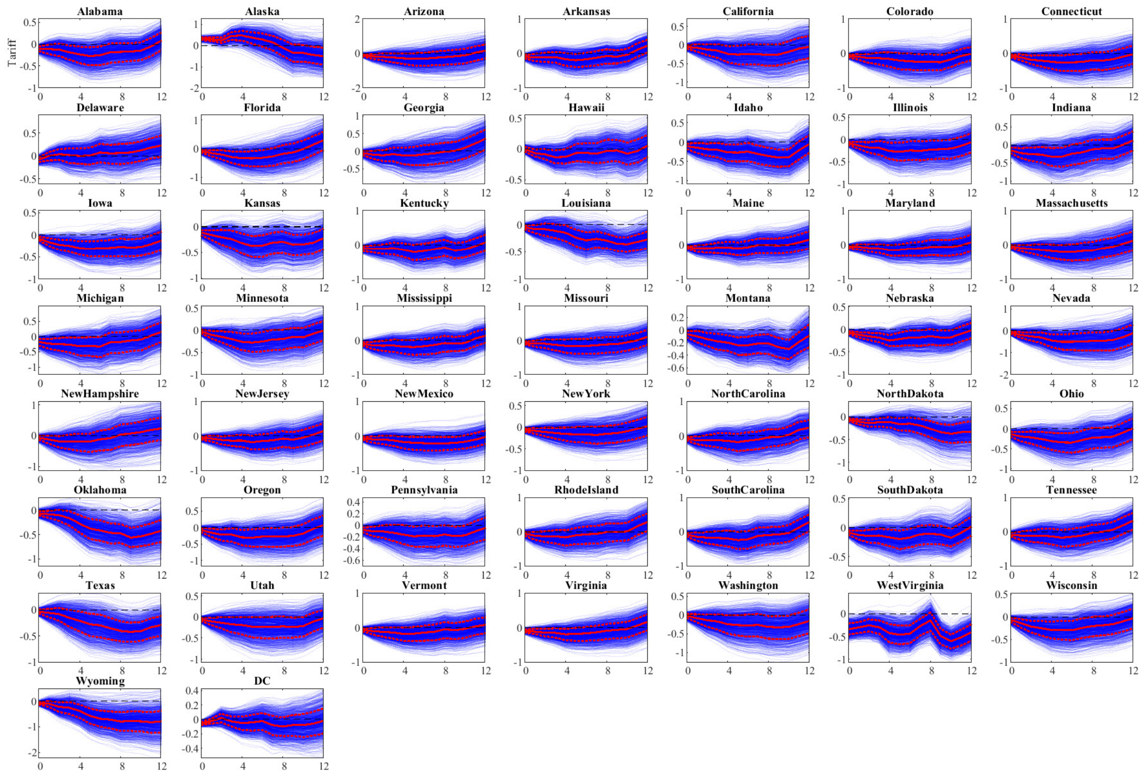
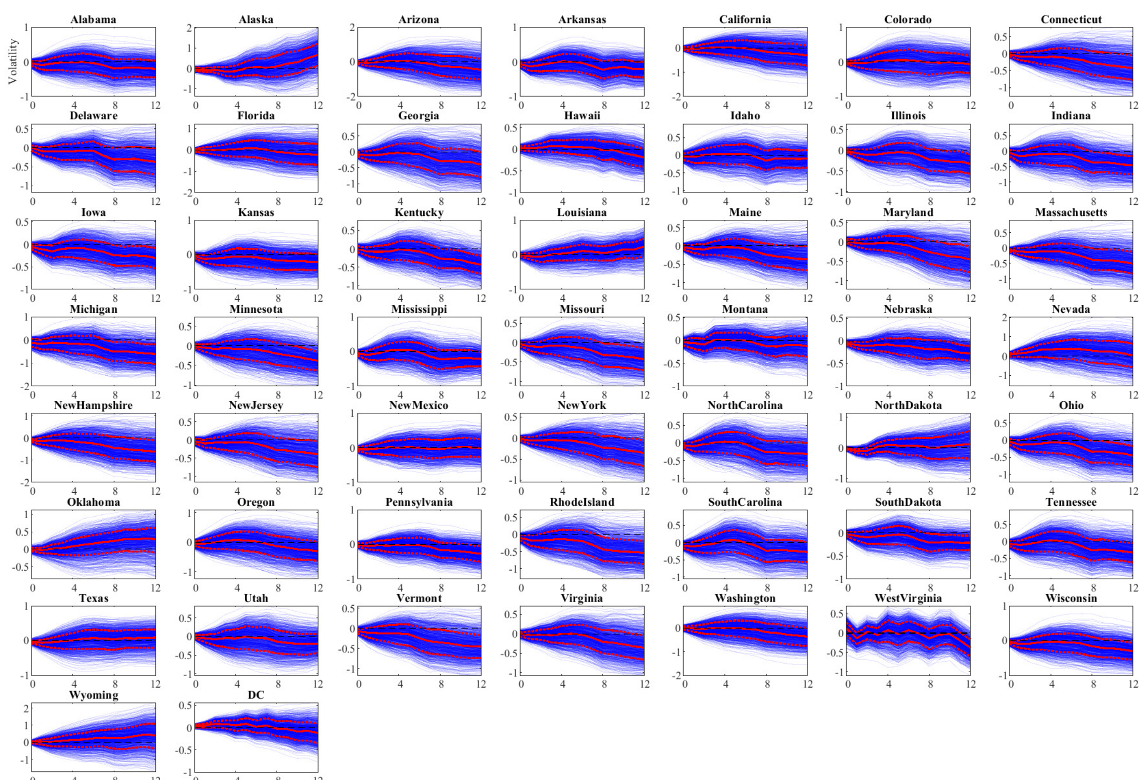


Figure A.20: Responses of state employment to a trade policy uncertainty shock.



C.3 Sensitivity analysis

C.3.1 Narrative Restrictions

We re-estimate our baseline model with different sets of narrative restrictions from Table 2 and present the results for the impulse responses and the forecast error variance decomposition. The specifications include our baseline ('Base'), no narrative restrictions ('No'), or combinations of the restrictions, for example, '71/75' for the level and uncertainty restrictions in the years 1971 and 75 only.

Figure A.21: Impulse responses. *Notes:* The figure shows the point-wise median effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters under different narrative restrictions.

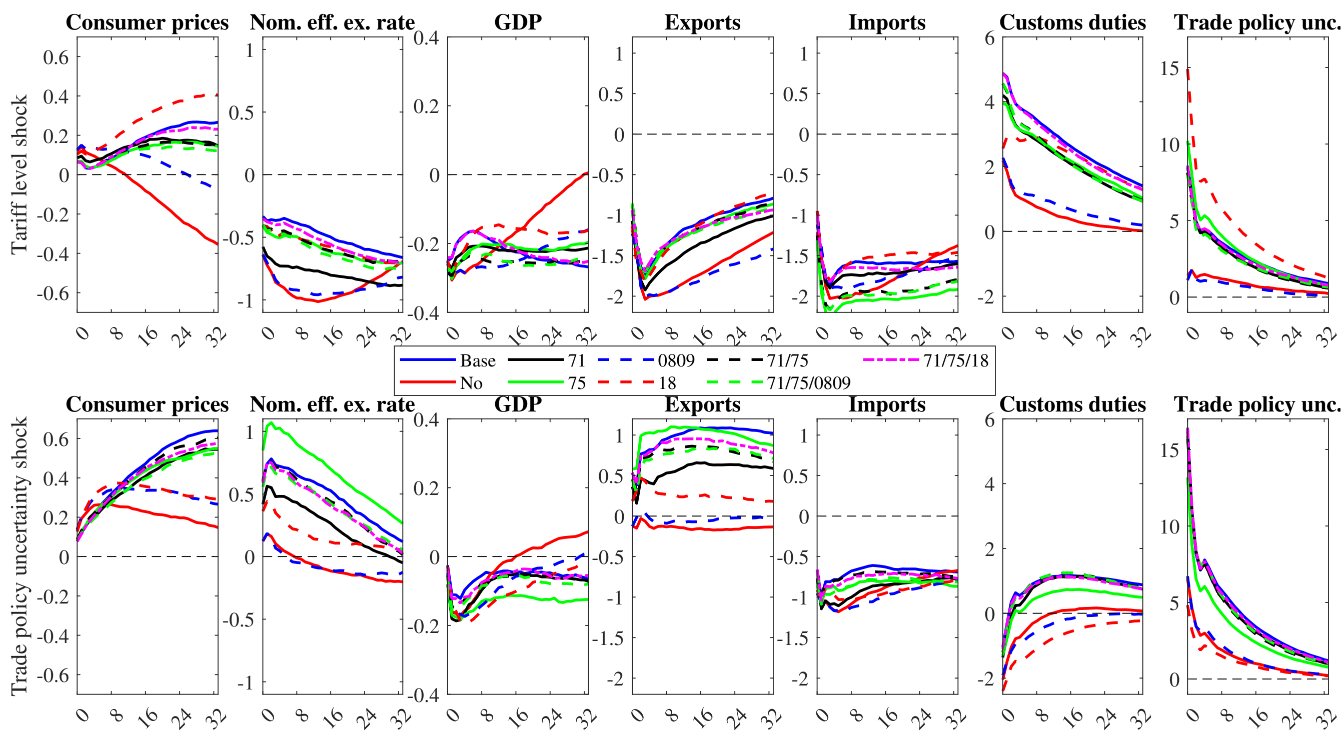
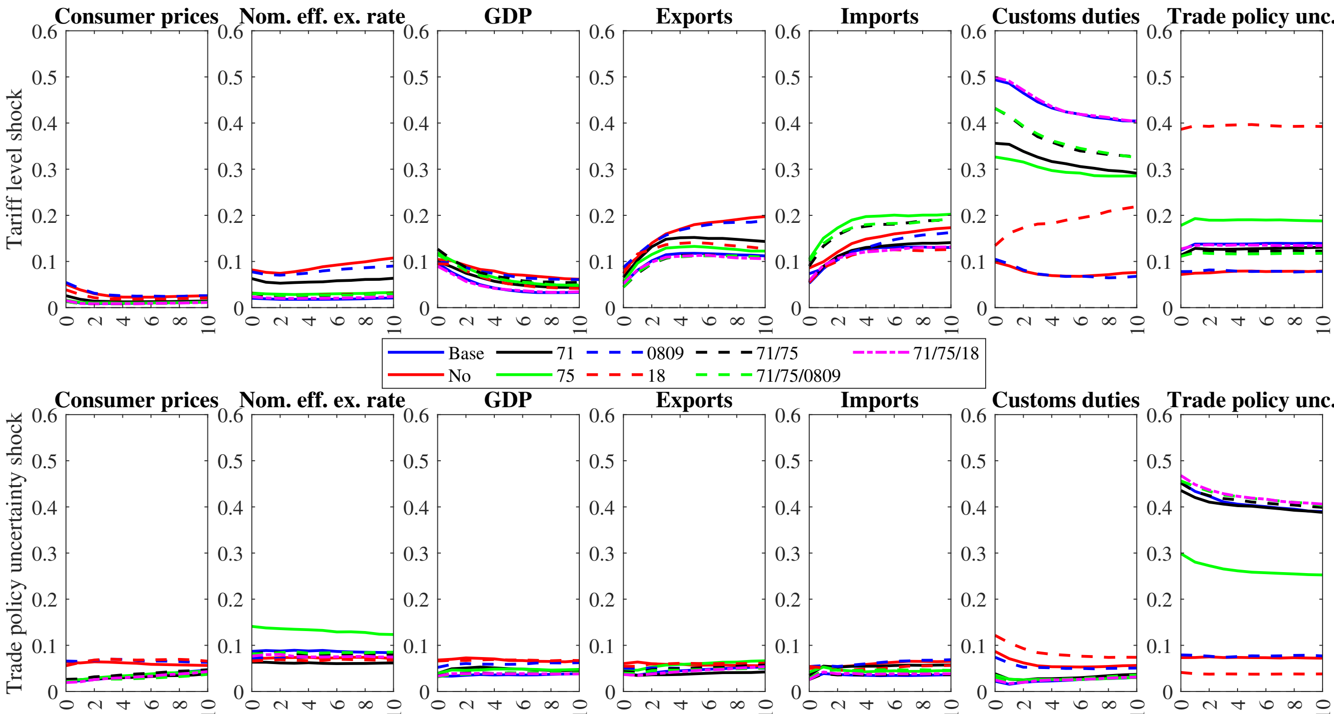


Figure A.22: Forecast error variance decomposition. *Notes:* The figure shows the point-wise median of the percentage of the forecast error variance of the endogenous variables (in columns) due to tariff level shocks in the upper panels and due to trade policy uncertainty shocks in the lower panels over a horizon of 32 quarters across different narrative restrictions.



C.3.2 Realized Tariff Volatility

We replace the trade policy uncertainty index with realized tariff volatility from a particle filter following Born and Pfeifer (2014); Fernández-Villaverde et al. (2015); Caldara et al. (2020). The tariff rate follows an autoregressive process with stochastic volatility as postulated in our theoretical model:

$$\begin{aligned} \tau_t &= (1-\rho_\tau)\,\mu_\tau + \rho_\tau \tau_{t-1} + exp(\omega_\tau)\varepsilon_t, \quad \varepsilon_t \sim N(0,1) \\ \omega_t &= (1-\rho_\omega)\,\omega + \rho\omega_{t-1} + \eta\nu_t, \quad \nu_t \sim N(0,1). \end{aligned}$$

The estimated parameter values in Table A.3 display high persistence of both the level and the realized volatility series. A one standard deviation shock to tariff volatility (ν_t) raises the standard deviation of innovations to the tariff level by 100 $exp(-6.34+0.37) = 0.26\%$ points. The impulse responses (Figure A.23) to a realized tariff volatlity shock–based on the same narrative restrictions as the baseline model–show a strong increase in realized tariff volatility, whereas customs duties drop persistently. Exports tend to rise and imports decrease similarly as in the baseline model. The GDP effects are negative and larger (in absolute value) than in the baseline model.

Parameter	Median	5th ptile	95-th ptile
ρ_τ	0.996	0.992	0.998
ω	-6.339	-6.714	-5.771
ρ_ω	0.916	0.813	0.964
η	0.374	0.296	0.484

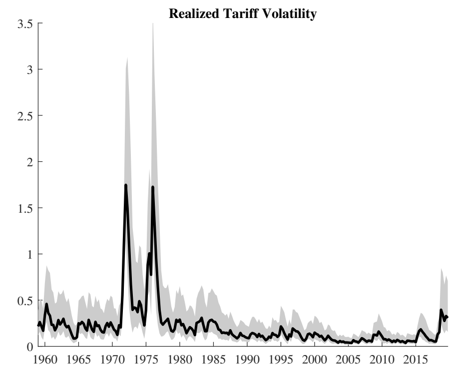
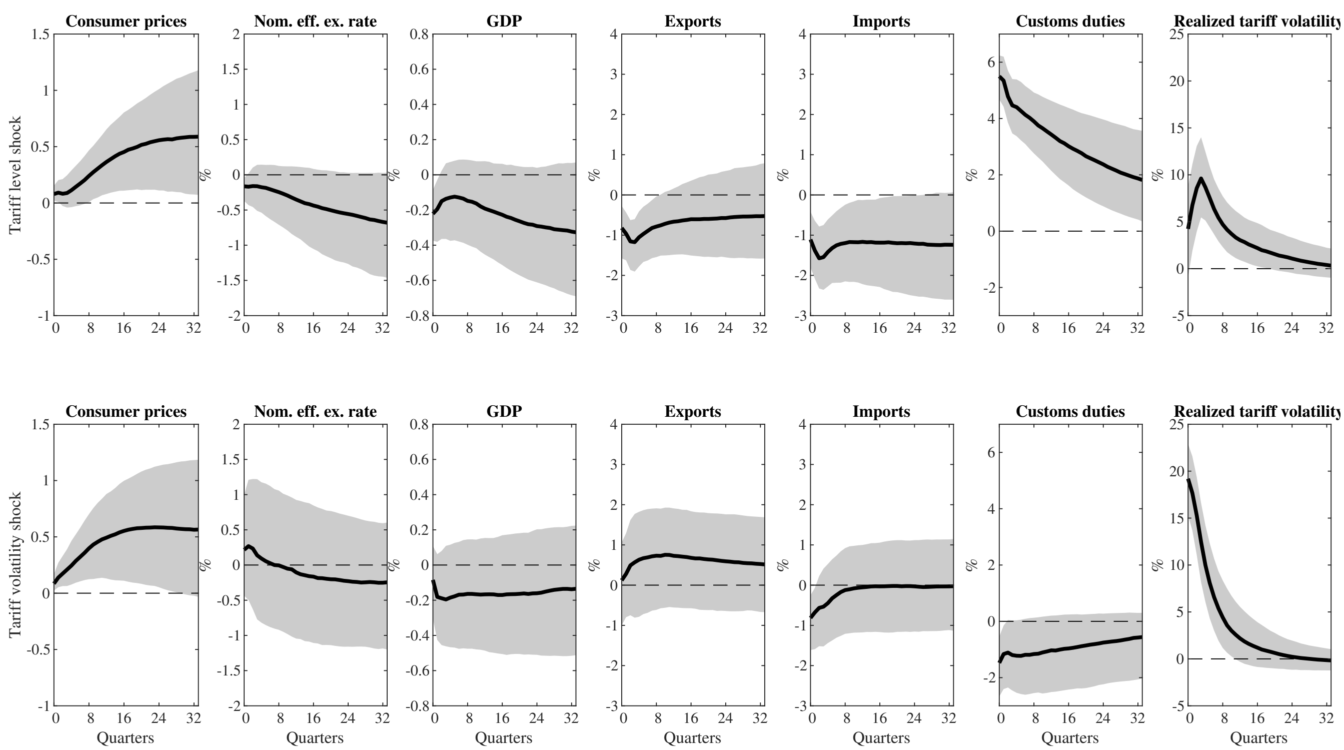


Table A.3: Parameters and Realized Tariff Volatility Series

Figure A.23: Impulse Responses with realized tariff volatility. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to realized tariff volatility (lower panels) over a horizon of 32 quarters in the US. The solid lines show the point-wise median estimates and the shaded areas the 68% highest posterior density credible sets.



C.3.3 Further Specifications

Figure A.24: Impulse responses with consumption. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when replacing output by total private consumption.

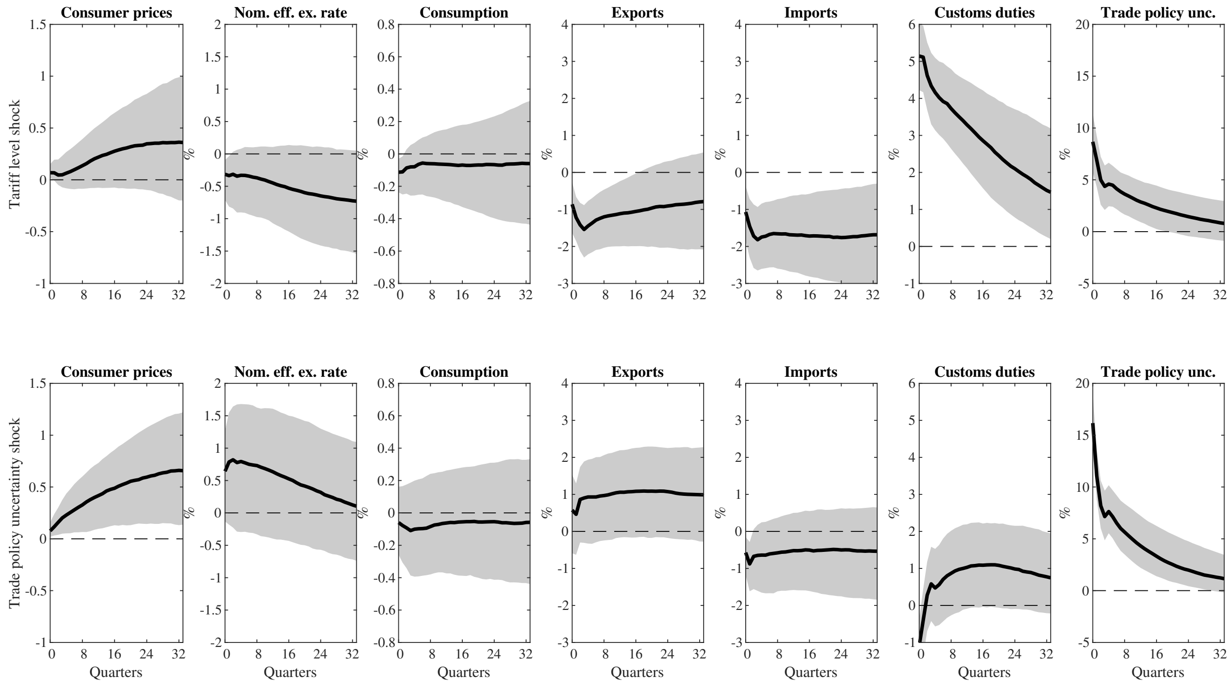


Figure A.25: Impulse responses with investment. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when replacing output by investment.

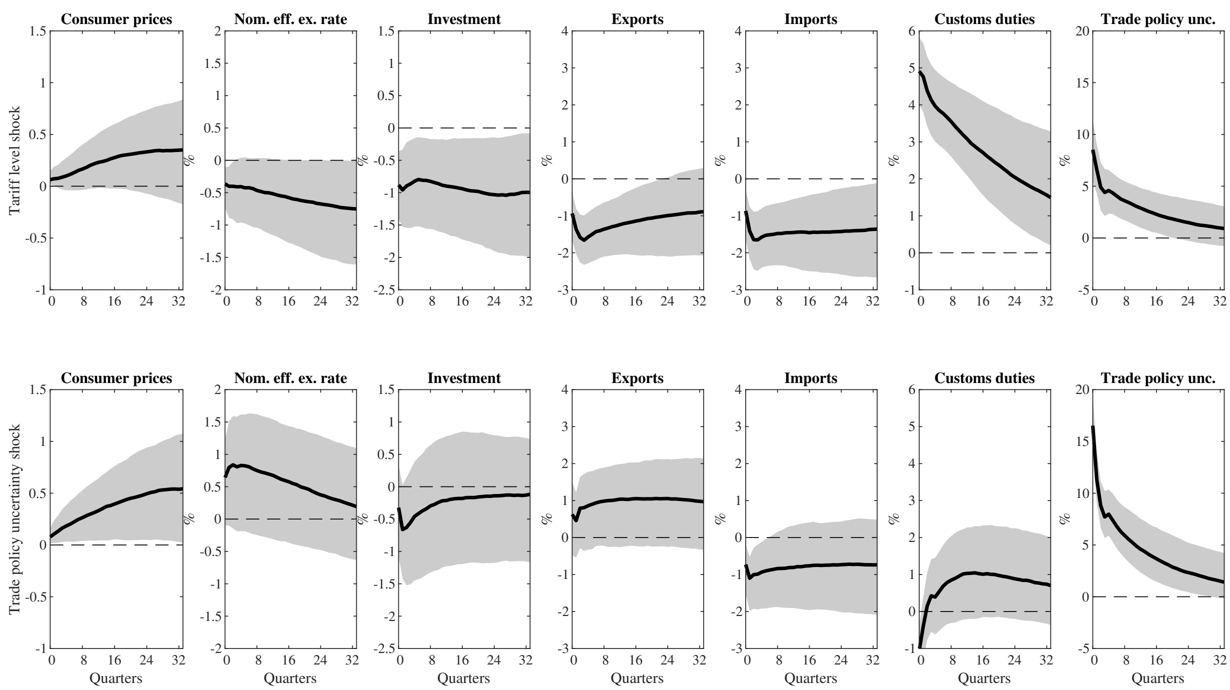


Figure A.26: Impulse responses with employment. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when replacing output by non-farm payrolls.

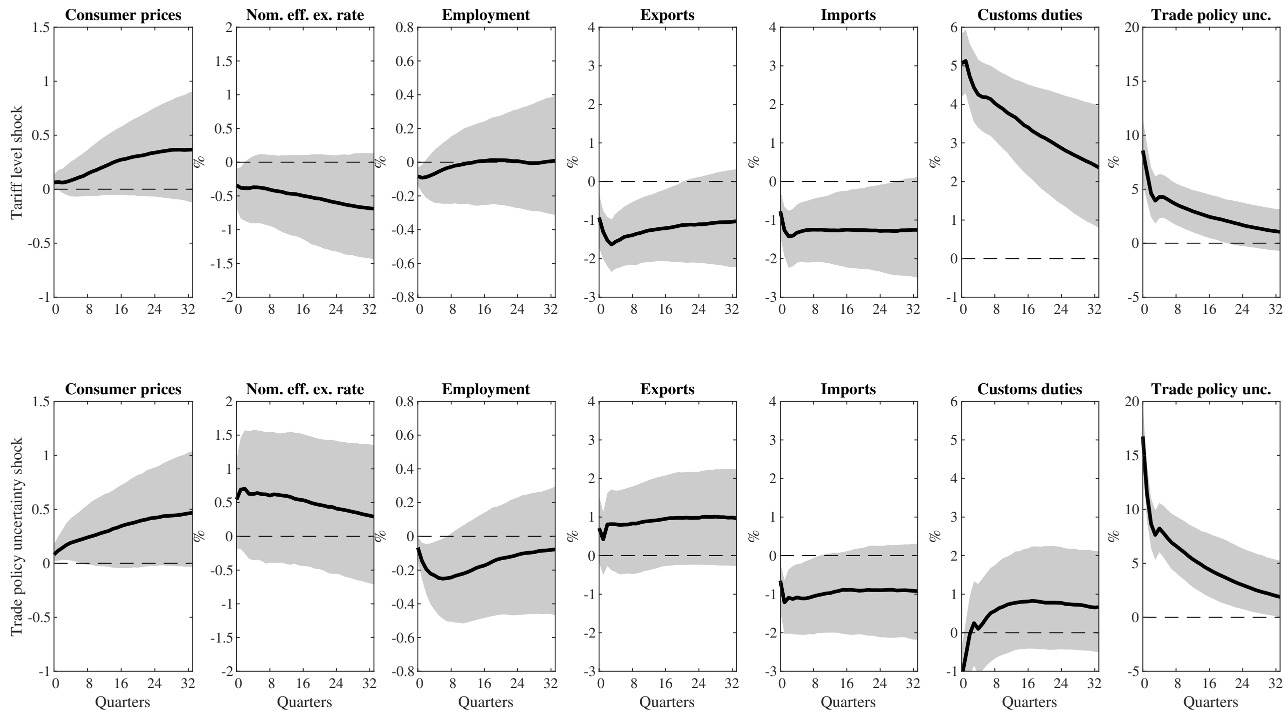


Figure A.27: Impulse responses when using the real effective exchange rate. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when using the real instead of the nominal exchange rate (an increase is a depreciation).

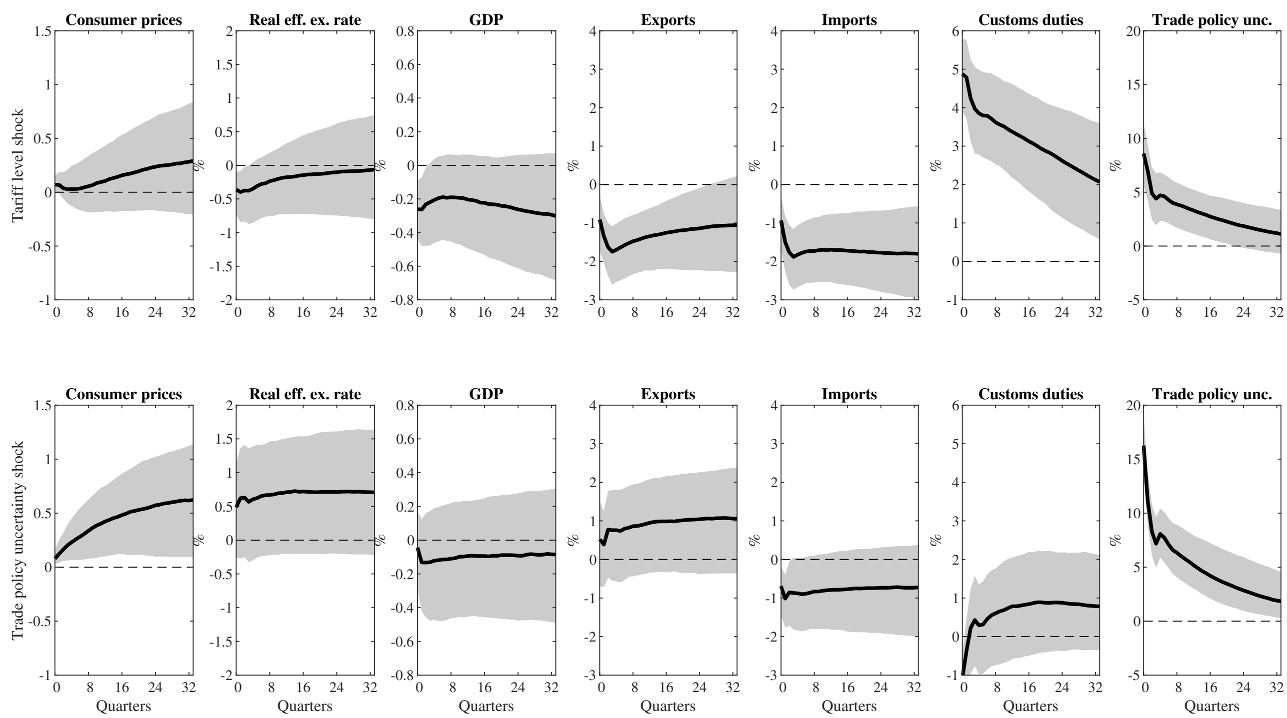


Figure A.28: Impulse responses when using producer prices. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when using the producer instead of consumer prices.

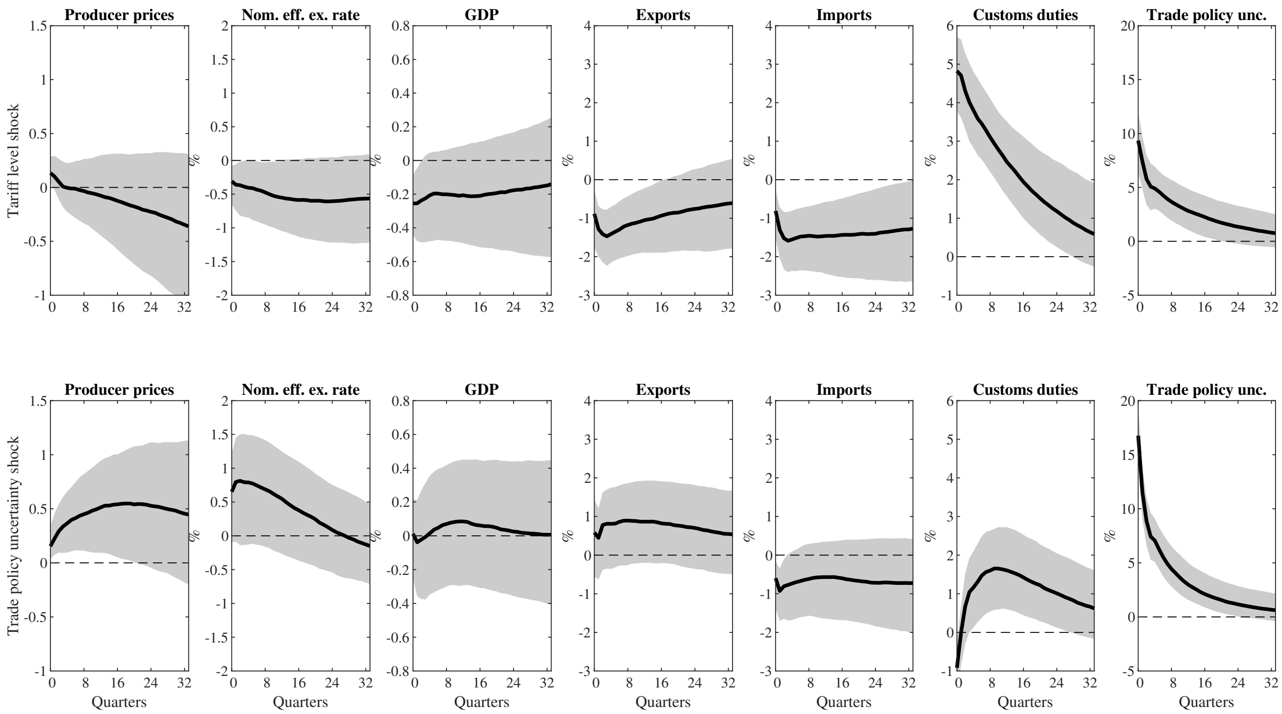


Figure A.29: Impulse responses with trade balance. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when adding the ratio of net exports to GDP.

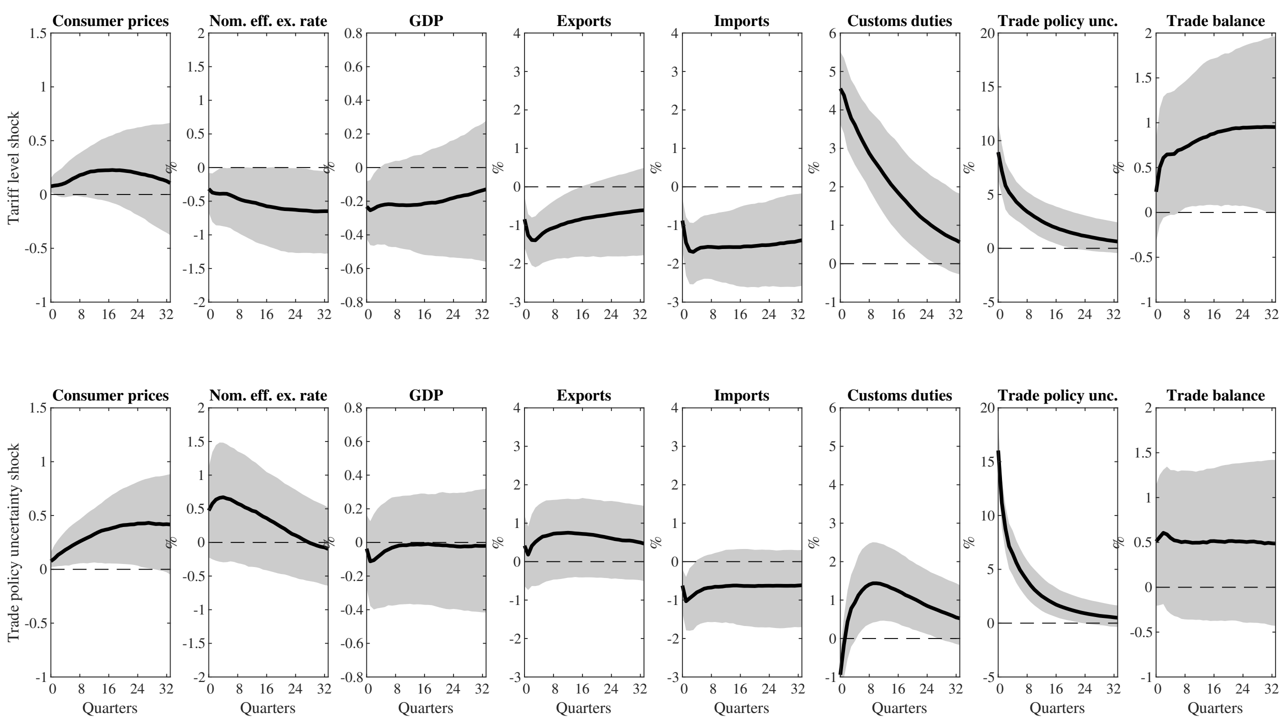


Figure A.30: Impulse responses with terms of trade. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when adding the terms of trade.

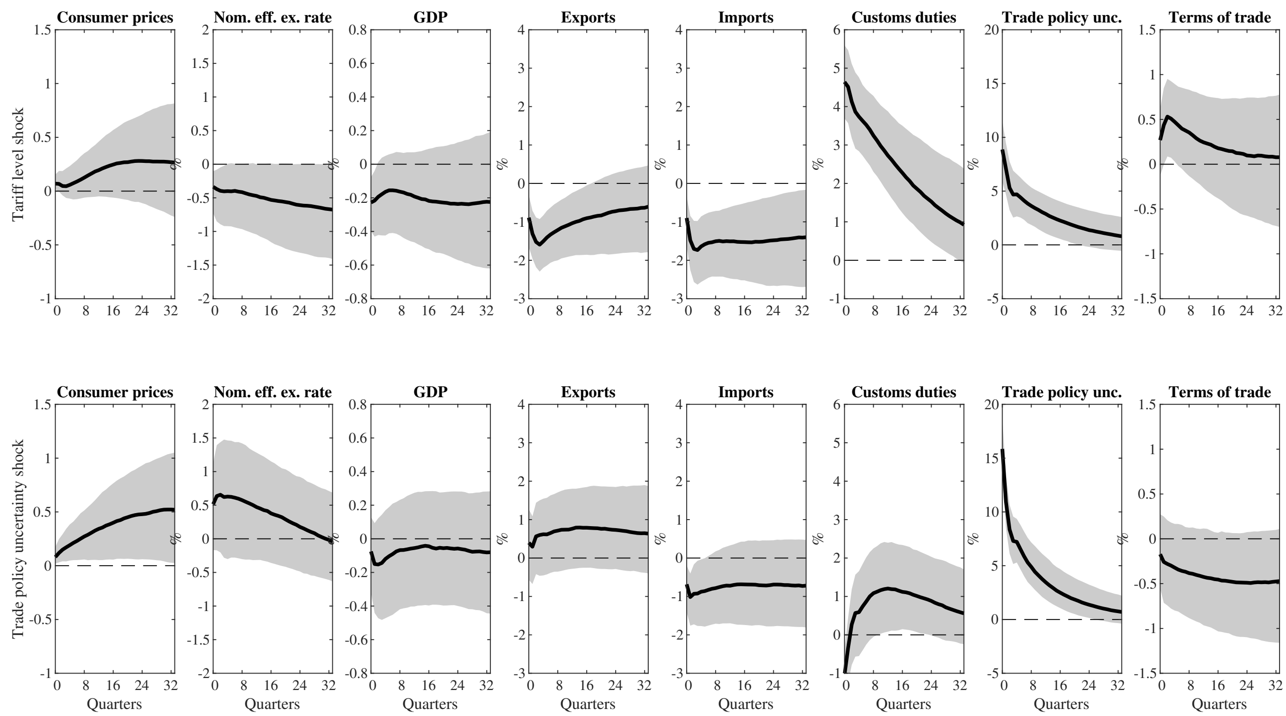


Figure A.31: Impulse responses for sample ending in 2016Q4. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when the sample ends in 2016Q4.

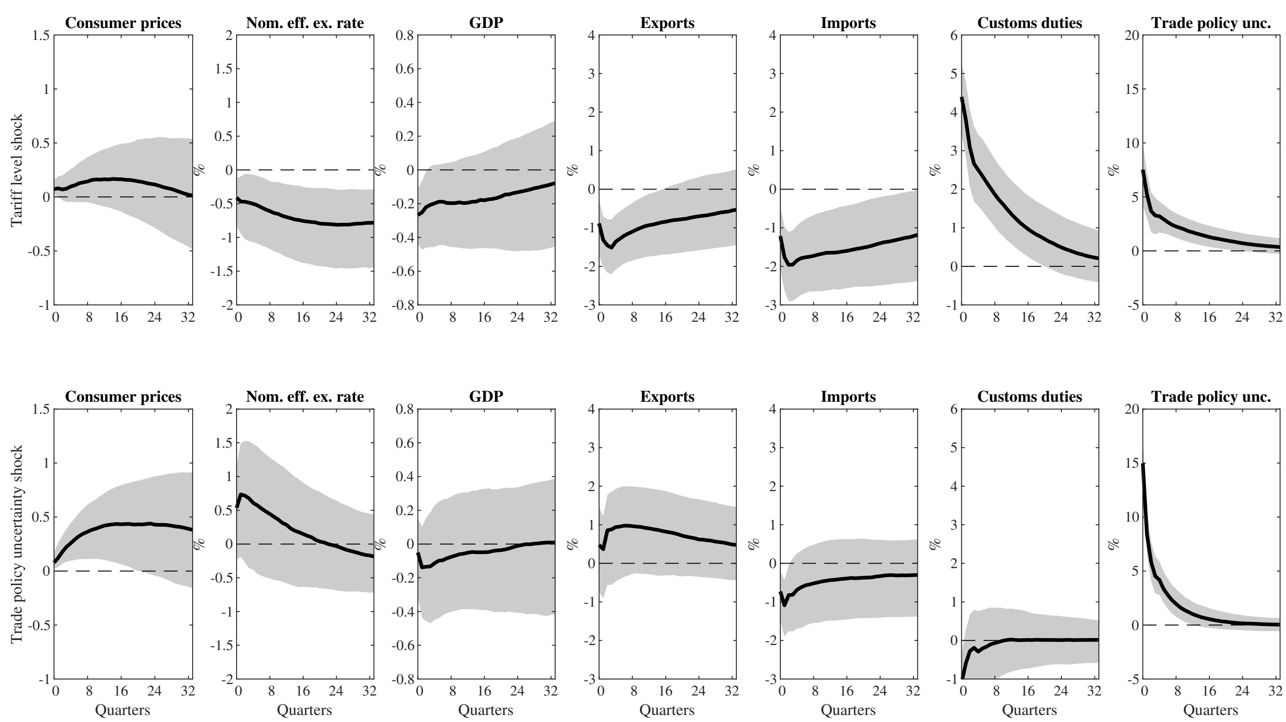


Figure A.32: Impulse responses using two lags. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when using eight lags of the endogenous variables.

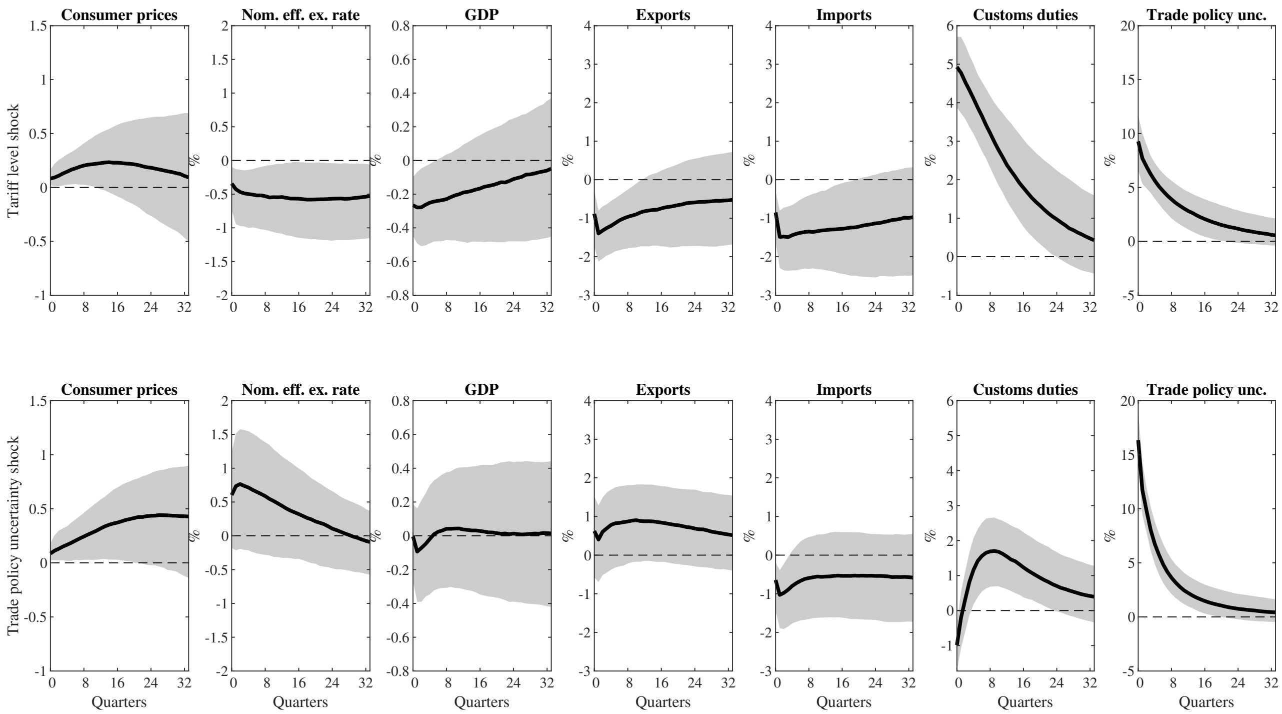


Figure A.33: Impulse responses using six lags. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when using eight lags of the endogenous variables.

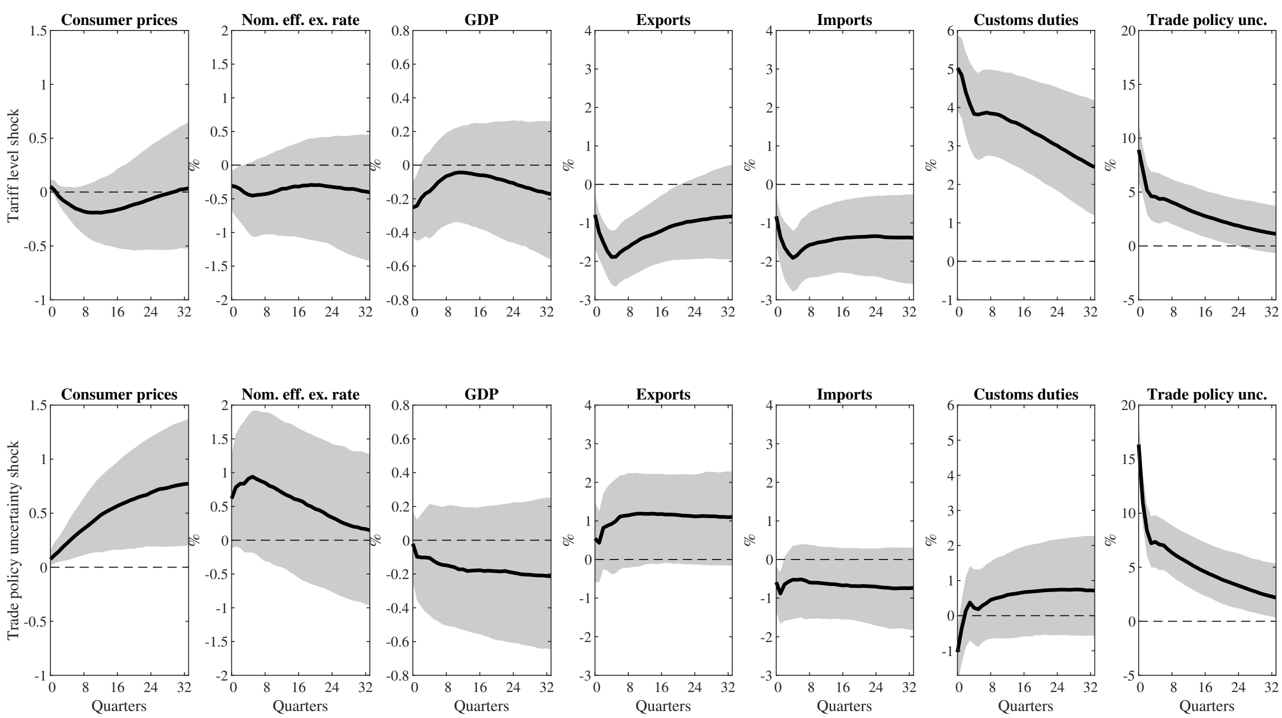


Figure A.34: Impulse responses with total factor productivity. *Notes:* The figure shows the effects of a positive one standard deviation shock to import tariffs (upper panels) and to trade policy uncertainty (lower panels) over a horizon of 32 quarters in the US when adding TFP (total factor productivity). The solid lines show the point-wise median estimates and the shaded areas the 68% highest posterior density credible sets.

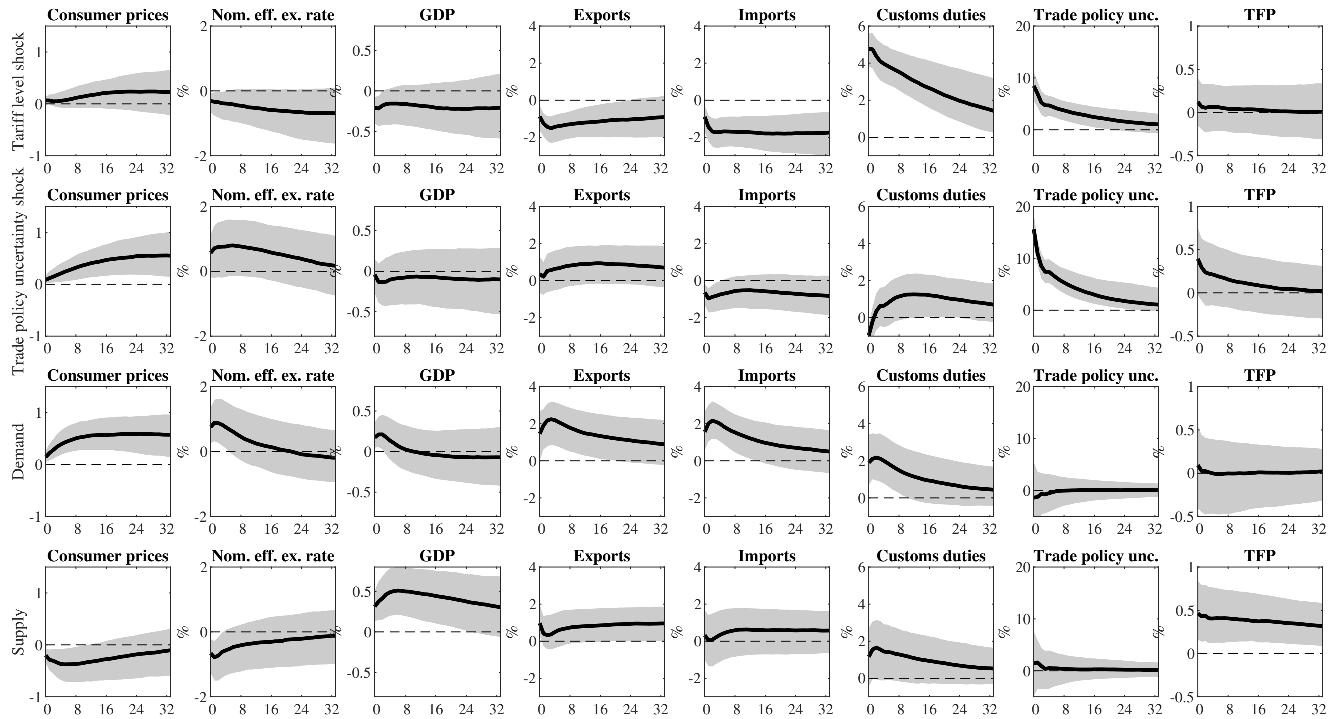


Figure A.35: Impulse responses with monetary policy shock. *Notes:* The figure shows the structural impulse responses to a tariff level shock, a trade policy uncertainty shock, a domestic demand shock, a domestic supply shock, and a domestic monetary policy shock in rows on the endogenous variables in columns. It reports point-wise median impulse responses and 68% highest posterior density credible sets. Identification assumes that the monetary policy shock raises the federal funds rate on impact and lowers prices, GDP and the nominal exchange rate.